DEPARTMENT OF THE AIR FORCE
Air Force Office of Scientific Research (AFRL)
801 North Randolph Street, Room 732
Arlington VA 22203-1977

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RESEARCH INTERESTS OF THE AIR FORCE OFFICE OF SCIENTIFIC RESEARCH And BROAD AGENCY ANNOUNCEMENT 2000-1

FOREWORD

The Air Force Office of Scientific Research (AFOSR) manages the entire basic research investment of the US Air Force. AFOSR's technical experts foster support and conduct research within the Air Force, university and industry laboratories to ensure the transition of research results to support USAF needs. Using a carefully balanced research portfolio, these research managers create new technology and advance current knowledge, enabling users in the Air Force and U.S. industry to produce world-class, militarily significant, and commercially valuable products.

In Fiscal Year 1998, AFOSR managed funding support for approximately 1,213 grants, cooperative agreements and contracts, totaling $238 million, to about 334 academic institutions and industrial firms. These included grants to university scientists, academic institutions, contracts for industry research, and cooperative agreements. In addition, this also included AFOSR-managed basic research programs funded and awarded by the Department of Defense (DoD), Defense Advanced Research Projects Agency (DARPA), and Ballistic Missile Defense Organization (BMDO). The Broad Agency Announcement (BAA) for those programs can also be accessed through AFOSR’s web page at http://www.afosr.af.mil.

AFOSR encourages the sharing and transfer of technology. Therefore, AFOSR welcomes proposals that envision cooperation among two or more partners from academia, industry, and Air Force organizations. Non-industry proposers should spell out in their proposals their interactions with industry and Air Force organizations, including specific points of contact. AFOSR also encourages proposers to cooperate with or use Air Force facilities; proposers should contact appropriate directorates in AFRL for this purpose. The *Directory* included in this document provides some initial contact points.

This document will guide proposers through AFOSR's research program and facilitate their preparation of research proposals. It is available on the AFOSR web site at http://www.afosr.af.mil. A very limited number of hard copies are available for individuals without access to the AFOSR home page. To request a hard copy, contact AFOSR/PI at (703) 696-9513.

This document is divided into seven sections:

The *Introduction* describes the Broad Agency Announcement (BAA), the mechanism AFOSR uses to solicit research proposals. It also provides an overview of the general approach used to submit proposals. AFOSR’s foreign research offices, in London (the European Office of Aerospace Research and Development--EOARD) and Tokyo (the Asian Office of Aerospace Research and Development--AOARD) also utilize this BAA. EOARD and AOARD manage programs that provide access to international research and research organizations of interest to the Air Force and other DoD agencies. In Fiscal Year 1998, EOARD and AOARD awarded 122 contracts totaling $3.518 million to research universities and institutions from African, Asian, European, Middle Eastern, and Pacific Rim countries. In addition, EOARD had 14 modifications to previous year contracts totally $735K. (See **EOARD** and **AOARD** homepages for more information via the AFOSR home page at: http://www.afosr.af.mil under International Offices.)

The *New World Vistas* (NWV) section describes the science and technology areas identified in the Air Force Scientific Advisory Board's NWV report. Proposals are accepted in these areas which support the six future Air Force capability areas: Global Awareness, Dynamic Planning and Execution Control, Global Mobility in War and Peace, Projection of Lethal and Sub-Lethal Power, Space Operations, and People.

The *Research Interests* section describes the basic research conducted within each directorate that AFOSR is interested in sponsoring.

The *Researcher Assistance Programs* section discusses associateships, faculty, and graduate school research programs. Most of these programs are designed to foster the mutual research interests of both the Air Force laboratories and institutions of higher education.

The *Proposal Guidance* section is to be used in conjunction with the *AFOSR Proposer's Guide* for submitting a proposal in response to this announcement.

The *Directory* lists the names, telephone numbers, mailing addresses, and e-mail addresses of AFOSR scientific directors and program managers, and the names, telephone numbers, and mailing addresses of Air Force chief scientists.

Anyone qualified to perform research is encouraged to contact AFOSR in accordance with the appropriate BAA and the guidelines given in this pamphlet. We particularly encourage proposals from historically black colleges and universities, minority institutions, and minority researchers.

Original signed by

JOSEPH F. JANNI
Director

I. INTRODUCTION

The Air Force Office of Scientific Research (AFOSR) manages all basic research investment for the U.S. Air Force under this Broad Agency Announcement (BAA). To accomplish this task, AFOSR solicits proposals for research through this general BAA and specialized BAAs. All BAAs are published in the *Commerce Business Daily* (*CBD*).[1]

This BAA outlines the Air Force Defense Research Sciences Program and is reprinted in Section VI, *Proposal Guidance,* for your convenience. AFOSR invites proposals for basic research in many broad areas. Sections II through V of this document describe those areas in greater detail.

"Specialized BAAs outline specific programs in which the Air Force has a high interest or which target a specific section of the research community. Examples of specialized BAAs previously released are BAA 98-4 "Innovative Computational Mathematics for Physical Applications, BAA 98-5 which solicited requests for research equipment from colleges and universities, and BAA 98-6 which focused on special satellite technology issues. The DoD/AF also periodically releases BAAs or Program Solicitations targeting small businesses involved in research (the SBIR/STTR program solicitations) or Historically Black Colleges and Minority Institutions. Fiscal Year 1999 listing of MIs may be viewed at http://www.ed.gov/offices/OCR/99minin.html. Portions of this document may be applicable to the research opportunities described in the specialized BAAs. Current BAA and program solicitations are listed on the DoD URI website or AFOSR's home page under "Research Opportunities."

(http://www.dtic.mil/dtic/urs.html) (http://www.afosr.af.mil)

Each BAA specifies deadlines, proposal formats, and other unique requirements. Unnecessarily elaborate brochures or presentations beyond those sufficient to present a complete and effective proposal are not desired. All proposals must be submitted in hard copy form directly to the office listed in the applicable BAA. Be sure to mark your proposal with the specific BAA number to ensure that it receives proper consideration. Information about current BAAs is available from the address listed in the address section below. In addition, the *AFOSR Proposer's Guide* describes procedures to follow when submitting proposals.

Before submitting a research proposal, you may wish to further explore proposal opportunities. You can do this by contacting the AFOSR program manager, who can provide greater detail about a particular opportunity; the program manager may then ask for a preliminary proposal (see below). However, in your conversations with any Government official, be aware that only contracting and grants officers are authorized to commit the Government. Names and telephone numbers of AFOSR program managers are listed in Section VII of this document.

If you would prefer (or if the program manager requests), you may submit a preliminary proposal, which should be in letter format and briefly describe the proposed research project's (1) objective, (2) general approach, and (3) impact on Department of Defense (DoD) and civilian technology, as well as any unique capabilities or experience you have (e.g., collaborative research activities involving Air Force, DoD, or other Federal laboratories). Pre-proposal letters should not exceed three

[1] The *CBD* publishes synopses of proposed U.S. Government contract actions that exceed $25,000 in value. Subscriptions to the *CBD* are available from the Superintendent of Documents, Government Printing Office, Washington, DC 20402-9371, Tel. (202) 512-1800 or at web site http://cbdnet.gpo.gov.

typewritten pages; example figures and a one-page curriculum vita(e) for the principal investigator(s) may be attached.

Address Information:

We encourage you to obtain a copy of this BAA via the AFOSR home page website (http://www.afosr.af.mil). There will be a limited number of hard copies produced for individuals without access to the AFOSR home page. To request a hard copy, contact AFOSR/PI at (703) 696-9513. If you require additional copies of this document or other current AFOSR BAAs, send a self-addressed label with your request to

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AFOSR publications can be obtained by calling (703) 696-9513. DoD personnel can call DEFENSE SWITCH NETWORK (DSN) 426-9513. This pamphlet, as well as other AFOSR publications, may be downloaded from the Federal Information Exchange (FEDIX), an on-line information system accessible via computer and modem. Call the FEDIX computer at (800) 783-3349 (eight data bits, one stop bit, no parity). There is no charge to the user for accessing the information. The FEDIX help line is available at (301) 975-0103 from 8:30 a.m. until 5:00 p.m. EST. Also, FEDIX is accessible via Internet at the following Telnet address: "fedix.fie.com". At login, type "fedix" or Telnet to "192.111.228.33" or to Web server http://www.afosr.af.mil.

II. New World Vistas

The Air Force Office of Scientific Research (AFOSR) is specifically, but not exclusively, interested in sponsoring basic research that supports the science and technology areas identified in the Air Force Scientific Advisory Board's New World Vistas report. The New World Vistas contain recommendations and guidance that address technologies and concepts for the future Air Force. These six capability areas include: Global Awareness, Dynamic Planning and Execution Control, Global Mobility in War and Peace, Projection of Lethal and Sub-lethal Power, Space Operations, and People. The six areas have been further broken down into 41 science and technology subareas. The Air Force intends to invest in basic research that supports some or all of these subareas. These areas are described below.

Global Awareness

Point of Contact: Dr. Clifford Rhoades, Jr. (703) 696-7797

Network Data Fusion for Global Awareness

Point of Contact: Dr. Neal Glassman (703) 696-8431
A basic research program investigating the fundamental methods for optimizing the extraction of information and the discovery of knowledge to support military operations from ground, air, and space sensor systems, as well as from multiple intelligence and commercial data bases. The data from this wide range of sources must be combined to extract and organize information needed by war fighters and planners. Emphasis is on the development of object-oriented, symbol-based, and fusion techniques.

Lightweight Antenna Structures

Point of Contact: Dr. Spencer Wu (703) 696-8523
A basic research program investigating the key enabling technologies necessary to support revolutionary antenna structures for advanced high-altitude radar and communications platforms. Emphasis is on advanced high-specific-strength materials with affordable processing methods to enable efficient, lightweight, reduced-observability deployable antennas, sparse apertures, and integrated structures.

Low-Cost, Lightweight Membrane Structures

Point of Contact: Dr. Charles Lee (703) 696-7779
A basic research program investigating the key enabling technologies necessary to support implementation of large space-deployable reflective surfaces for radar and optical apertures. Emphasis is on low-cost processing of innovative materials and coatings for lightweight membrane structures. This activity supports radar, imaging sensors, communications, laser collimators, and solar collectors and will be conducted in coordination with Precision Deployable Large Antennas/Optics.

In Situ Sensor

Point of Contact: Maj Dan Johnstone (703) 696-7545
A basic research program investigating the key enabling technologies necessary to support implementation of stable, narrow-line semiconductor lasers operating in the ultraviolet, mid-infrared, and infrared ranges for use in unattended ground detection of nuclear, biological, and chemical (NBC) agents and for secure communication of this information. At low powers, these lasers will be used for chemical detection of NBC agents. This data will be stored until the unit is interrogated by a vehicle using a laser communication system. A higher power semiconductor laser will uplink to the vehicle.

Global Awareness Virtual Testbed

Point of Contact: Dr. Neal Glassman (703) 696-8431
A basic research program to develop the capability to evaluate a wide range of global awareness technologies. This effort will create a multisite virtual testbed to analyze capabilities obtainable from the next generation of sensor systems. Emphasis is on development of system wide metrics that permit measurement of information gains for sensors, communications, and fusion-processing functions. Relevant technologies include global sensor networks, global communications, multilevel fusion, commercial databases, decision aids, and information displays.

Low-Noise/High-Uniformity Broadband Sensors

Point of Contact: Maj Dan Johnstone (703) 696-7545
A basic research program investigating the key enabling technologies necessary to support implementation of detectors for multispectral, hyperspectral, and ultraspectral sensor applications. Emphasis is on low-noise, high-quantum-efficiency, high-temperature, high-uniformity, broadband and multispectral detectors. Exploration of the unique sensing systems used by biological systems, and integration of these biological concepts into electronic systems with similar capabilities, will also receive attention.

Dynamic Planning and Execution Control

Point of Contact: Dr. Clifford Rhoades, (703) 696-7797

Planning and Scheduling

Point of Contact: Dr. Neal Glassman (703) 696-8431
A basic research program investigating the key enabling technologies necessary to support advanced planning and scheduling systems. Emphasis is on technology related to collaborative planning and decision-making, joint war fighter training, and integrated operations and real-time intelligence and surveillance planning and scheduling that allow for degraded sensors and components. This activity provides the foundation for continuous planning in a distributed environment with multiple decision makers and for information visualization using data walls and virtual reality techniques.

Communications

Point of Contact: Dr. Jon Sjogren (703) 696-6564
A basic research program investigating the key enabling technologies that will enhance the connectivity of the aircraft to the communications grid. Emphasis is on coding; distributed computing; adaptive routing protocols; normal, efficient antenna concepts; and carrier modulation techniques. This project relates to different aircraft tying into different networks with different waveforms using software-oriented radios.

Knowledge Bases

Point of Contact: Capt Freeman Kilpatrick (703) 696-6565
A basic research program supporting new classes of intelligent battlefield systems by investigating the technology to allow system developers to build large-scale knowledge bases (millions of objects) quickly and economically. The overall goal is to reduce, by a factor of 10, the time required to construct large-scale knowledge base systems.

Intelligent Agents for Air Force (AF) Battlefield and Enterprise Information Assistants

Point of Contact: Capt Freeman Kilpatrick (703) 696-6565
A basic research program investigating the key enabling technologies to construct the leading edge of AF-specific intelligent agents. Specific technology challenges include: (1) retrieving information from AF data bases based on AF and Department of Defense content, (2) linking AF planning tools with the large knowledge bases and data bases, (3) filtering and summarizing AF information, (4) shielding users from complexity of computer processes and interfaces, and (5) other tasks of human-machine coupling. This activity encompasses agents that perform reasoned actions as well as agents that learn their actions and controls the flood and expanse of information pouring through our networks.

Information Warfare

Point of Contact: Capt Freeman Kilpatrick (703) 696-6565
A basic research program investigating the most likely evolutionary paths for computer viruses and other types of malicious code. Emphasis is on the application of rigorous computer science methods with a particular focus on the threats to control code passing through an unbounded domain. The AF will make heavier use of commercial communication systems for military traffic in the decades to come. In addition, use of radio frequency communications will increase to support theater battle management and other AF activities. Both trends offer opportunities for controlling both data and codes while in transit through an unbounded domain. This research attempts to understand how software attacks will be made and to determine the fundamental computer science issues associated with detection and prevention.

New Models of Computation

Point of Contact: Dr. Marc Jacobs (703) 696-8409
A basic research program investigating computational mechanisms such as those based on quantum computation or the use of DNA molecules or atomic-level storage and processing. Such methods may ultimately prove viable for non-real-time data fusion and scheduling applications. These applications can be modeled as combinatorial search problems in which non-real-time solutions are useful, particularly when extremely large databases are involved. DNA calculations are realized by performing biochemical operations on molecules that represent binary sequences. While the minimum time required to complete a problem is likely to be measured in minutes or hours, the

number of operations completed per unit time dwarfs that for electronic computers. The goal of this research is to determine whether these models of computation will prove viable.

Domain-Specific Component-Based Software Development

Point of Contact: Capt Freeman Kilpatrick (703) 696-6565
A basic research program investigating the key enabling technologies necessary to revolutionize software development time and cost by exploiting the two most promising avenues of software reuse: domain-specific architectures (DSA) and the construction of big software systems from off-the-shelf government and commercial components. DSA requires organizing and representing knowledge of function, performance (and other design parameters), equipment, and processes in AF domains. Component-based construction requires developing methods exploiting that knowledge during instantiation of DSA by components. Both methods require the development of languages for component description and component integration, including noncode assets.

Global Mobility in War and Peace

Point of Contact: Dr. Lyle Schwartz (703) 696-8457

Precision Air Delivery

Point of Contact: Dr. Steven Walker (703) 696-6962
A basic research program investigating the key enabling technologies necessary to support a high altitude/high standoff range aerial delivery process, leading to global, point-of-use, precision delivery of cargo directly to the war fighter.

The basic research issues for PAD include guidance, navigation and control, (aircraft and drop containers), advanced materials and structures for drop containers, characterization of drop container trajectories (during freefall and under the action of a drag device), precision container deceleration devices, aerodynamics and shaping of drop containers, structural morphing for aero-control of containers, real time drop zone meteorological assessment including advanced wind profiling techniques (these include LIDAR real-time wind profiling, GPS dropsonde systems, low power color weather radar systems, and possibly others yet to be identified), cargo handling techniques (on board and on/off loading), and Computed Air Release Point (CARP) algorithm development.

Composite Materials and Structures

Point of Contact: Dr. Charles Lee (703) 696-7779
A basic research program investigating the key enabling materials and structures technologies necessary for the global-range airlifter and space vehicle concepts. Subprojects include the following:

a. High-temperature materials and structures: Investigates technologies for synthesizing and characterizing novel composite materials and coatings for cooled, uncooled, and protected vehicle components that will operate in severe environments.

b. Lightweight materials and structures: Addresses the necessary fundamental mechanics, materials, processing, fabrication/assembly, and design issues associated with the performance of preform composite materials in aerospace applications.

Low-Specific-Fuel-Consumption Propulsion

Point of Contact: Dr. Julian Tishkoff (703) 696-8478
A basic research program investigating the key enabling propulsion technologies necessary to support hyperendurance, long-range aircraft. Emphasis is on turbulence combustion modeling, ultrahigh-temperature materials, and combustion chemistry.

Aerodynamics and Controls

Point of Contact: Dr. Marc Jacobs (703) 696-8409
A basic research program investigating the key enabling technologies necessary to produce efficient cruise aircraft with lift-to-drag ratios approaching 40. Specific technology challenges include (1) active flow control and active control of nonlinear and smart structures, (2) new concepts of boundary layer control, (3) microelectromechanical systems technologies, (4) very high bypass propulsion streams and flow control, and (5) multidisciplinary optimal design.

Subsystem Integration/Power

Point of Contact: Dr. Spencer Wu (703) 696-8523
A basic research program investigating the key enabling technologies required by optimizing the efficiency and performance of a large airlifter at the integrated subsystem level (as total aircraft) beyond the conventional functional limit of individual subsystems (environmental control, electric, hydraulic, auxiliary, etc). Emphasis is on development of physics-based analytical models for the coupling effects and global minimization methods for the integrated system. Research focuses on fundamental issues including entropy generation minimization and instability behavior that are relevant in the operations of an advanced aircraft. Global minimization solution techniques will be generated with appropriate constraints, reflecting the multi-level engineering characteristics of the future subsystems.

Microelectromechanical Systems (MEMS)

Point of Contact: Dr. Howard Schlossberg (703) 696-7549
A basic research program investigating the design, fabrication, and testing of composite architectures engineered from the molecular level, incorporating new materials technology and analysis methods, including lessons learned from biological structures. New materials and processes will expand current MEMS capabilities, ultimately incorporating applications for severe environments. Methods for predicting the integrity of the interfaces between smart structures or MEMS embedded actuators and the host material will also be studied. A successful effort will enable the insertion of MEMS devices into both aging systems and new systems under development.

Active Defense Systems

Point of Contact: Dr. Robert Barker (703) 696-8574
A basic research program investigating the key enabling technologies for advanced air platform self-protection systems. Emphasis is on advanced technologies that will enable robust (effective against any and all threats) and affordable self-protection countermeasures. Candidate technologies include (1) high-power microwave, (2) lasers, (3) array jammers with adaptive intelligence, (4) plasma

cloaking for hypersonic vehicles, (5) aircraft kinetic kill, and (6) radar cross-section reduction using both active and passive technologies.

Battlefield Awareness/Weather Predictions

Point of Contact: Maj Paul Bellaire (703) 696-8411
A basic research program investigating the key enabling technologies necessary to enhance battlefield awareness. The systems include integration of data within the cockpit for use by the war fighter and data communicated from the aircraft to the battlefield for use by commanders and off-aircraft systems.

Human Systems Interface and Training

Point of Contact: Dr. John F. Tangney or Dr. Willard Larkin (703) 696-7793
A basic research program investigating the key enabling technologies to develop and demonstrate uninhabited combat aerial vehicle (UCAV) operator system concepts. This research includes the training requirements and methods necessary to effectively use the UCAV operator-vehicle interface in combat scenarios. Emphasis is on UCAV-like laboratory task performance analysis and modeling, leading to operator station concepts and training paradigms.

Projection of Lethal and Sub-lethal Power

Point of Contact: Dr. Lyle Schwartz, (703) 696-8457

Family of Uninhabited Aerial Vehicles (UAVs)

Point of Contact: Maj Brian Sanders (703) 696-7259
A basic research program investigating the key enabling technologies necessary to support the whole family of potential uninhabited aerial vehicles and UCAV concepts. Subprojects include the following:

a. High-efficiency, low-cost propulsion and power: Investigates technologies needed to provide the high fuel efficiency and energy storage for hyperendurance, high-altitude vehicles. The propulsion design options between fully person-controlled rated and expendable engines will be thoroughly explored. Ultrareliable, efficient, high-power-density power generation methods and energy storage materials will be considered.

b. Distributed architecture and high-bandwidth data exchange: Investigates the combination of flexibility, high capacity, jam resistance, data links, distributed architectures, and processing networks necessary for commanders to control multiple UAV functions or squadrons of UAVs.

c. Weaponization: Investigates small affordable munitions for UAVs to perform a wide range of lethal missions. Both directed-and kinetic-energy options merit additional study. Specific technology challenges include (1) high-energy-density propulsion, (2) high-energy and nonconventional warheads, (3) hardened missile dome materials, (4) small, multispectral modular seekers, (5) selectable warhead and propulsion profiles, (6) offensive and defensive laser and high-power microwave (HPM) directed-energy weapons, and (7) hypervelocity guidance and control.

d. High-strength, lightweight structures and materials: Investigates the innovative design and manufacturing of very low cost, high-strength structures and materials necessary to fully exploit the high performance levels permitted by removing the pilot's physical presence; to enable uncooled, high-cycle temperatures and simplified vehicle design; and to significantly improve the potential for affordable systems.

Hypersonics

Point of Contact: Dr. Julian Tishkoff (703) 696-8478
A basic research program investigating the key enabling technologies for hypersonic propulsion systems. Subprojects include the following:

a. Flow field research: Electromagnetic manipulation of ionized flow fields may offer potential for improving hypersonic vehicle lift-to-drag ratios and for tailoring inlet flow fields and rocket nozzles. Understanding the physical phenomena involved in these processes may lead to very effective long-range vehicles with reduced aerodynamic heating loads. The current state of modeling capability lags that of other flight and propulsion technologies. Key requirements for viable models include (1) simplified models for fuel-air combustion chemistry, (2) models for turbulence-chemistry interactions under high-speed compressible flow conditions, and (3) models for high-speed aerodynamics. Assessments of candidate vehicle configurations must be based on actual mission performance criteria. Major issues include (1) vehicle drag variation, (2) scramjet inlet performance, (3) coupled engine-airframe performance under actual dynamic maneuver mission scenarios, and (4) combined cycle combustion.

b. Advanced propulsion: Investigates advanced propellants and cooling concepts to enable hypersonic Mach 8+ aeropropulsion and combined cycle propulsion. Hydrocarbon-fueled vehicles in sustained hypersonic flight will involve substantial heat transfer to the fuel prior to injection into the scram jet combustor. The design of the rockets and airbreathers will require combustion systems with the flexibility to inject and mix supercritical fluids as liquids, two-phase mixtures, or vapors. This requirement is unprecedented in conventional system designs. In addition, flight beyond Mach 8 with storable propellants may require innovative fueling and cooling approaches.

Lethal and Sub-lethal Directed-Energy Weapons

Point of Contact: Dr. Robert Barker (703) 696-8574
A basic research program investigating the key enabling technologies necessary to support the fotofighter concept, directed-energy force projection from and in space, and compact HPM lethal and sub-lethal weapons. Subprojects include the following:

a. Phased arrays of semiconductor laser diodes: Investigates the fundamental technology for the fotofighter concept. Specific technology challenges include the development and demonstration of (1) scaleable coherent arrays, (2) techniques for electronic beam steering and target tracking, and (3) laser integration concepts that support very high efficiency, lightweight designs for conformal mounting and operation.

b. Large, lightweight optics wavefront compensation: Investigates fundamental technologies required to engage terrestrial targets with lasers from space. Materials, structures, and designs for very large inflatable or membrane mirrors must be coupled with advanced mechanical control and advanced optical techniques for wavefront correction. Advanced optical materials, adaptive nonlinear optics, Brillouin enhanced four-wave mixing and adaptive mirrors will be investigated for correction of laser beam distortion.

c. Lightweight, efficient microwave components: Provides the fundamental tools and the physics and technology database necessary for the development of HPM directed-energy weapons for space and UCAV applications. Specific technology and science challenges include (1) the creation and evolution of plasmas under the influence of high-power electromagnetic fields, (2) ultrawideband sources of microwave radiation, (3) the optimization of antennas required to efficiently project microwave power, both narrowband and ultrawideband, and (4) the physics and technology of frequency agile narrowband HPM sources.

d. Compact high-voltage pulsed power: Investigates the fundamental enabling technology required for packaging several types of directed-energy weapons. Specific basic research topics include (1) investigation of high-power-density, low-mass opening and closing switches and transformers, (2) flux compression generators employing conducting shock-front armatures, and (3) novel high-energy-density storage technology and techniques for rapid energy release.

e. Bioeffects: Investigates the biological effects of novel directed energy emissions in both acute and chronic exposure conditions. The effects of pulse shapes, modulation schemes, peak power, and other parameters of directed-energy weapons systems on biological organisms will be studied.

Energy-Coupling Modeling and Simulation

Point of Contact: Dr. Michael Berman (703) 696-7781
A basic research program investigating the key enabling technologies necessary to support smarter, more precise, autonomous, all-weather, highly lethal weapons with minimal collateral damage. Emphasis is on modeling of (1) coupling of warhead energy into targets to multiply lethality, including exotic or unconventional kill mechanisms; (2) penetrating munition terradynamics (penetration physics and munitions steering); and (3) initiation physics of energetic materials.

Space Operations

Point of Contact: Dr. Jack Agee, (703) 696-8570

Microsatellites

Point of Contact: Dr. Gerald Witt (703) 696-8571
A basic research program investigating the key enabling technologies necessary to support implementation of small, low-cost satellites with short build-to-launch times. Technology challenges include (1) lightweight, deployable precision structures; (2) radiation-hardened, low-power microelectronics; (3) thermal control for single-chip operation; (4) onboard processing and large onboard data storage systems; and (5) low-power microelectric propulsion for precision station keeping and position changes.

Distributed Functionality

Point of Contact: Dr. Howard Schlossberg (703) 696-7549
A basic research program investigating the key enabling technologies necessary to support distributed satellites and related communications systems, both airborne and ground-based. Specific

technology challenges include (1) distributed synthetic aperture sensor systems for resolution enhancement, (2) pointing concepts and optimization of collateral systems, (3) survivability of distributed microsatellite systems, (4) autonomous control of satellite clusters, (5) layout and control of distributed systems, (6) satellite network functionality, and (7) lightweight, high-data-rate cross-links.

Precision Deployable Large Antennas/Optics

Point of Contact: Dr. Howard Schlossberg (703) 696-7549
A basic research program investigating the key enabling large-aperture technologies required for target identification and directed-energy delivery from space. Emphasis is on addressing the physical size, system quality, and alignment limitations, as well as creating concepts for compact, lightweight, compensated, deployable precision reflectors. The program brings together innovations in optical compensation, deployment concepts, smart mechanisms, ultralight reflector panels, and precision metrology. Key issues include (1) precision pointing stability, (2) directionality, (3) beam control, and (4) maximum obtainable resolution.

High-Efficiency Electrical Laser Sources

Point of Contact: Maj Dan Johnstone (703) 696-7545

A basic research program investigating the key enabling technologies necessary to support engaging terrestrial targets with lasers from space. Emphasis is on enhancing the coherency, stability, and power handling capability of high-efficiency, high-power semiconductor lasers. High-efficiency laser source technology will be congruous with space operation.

Space Object Identification and Orbit Prediction

Point of Contact: Dr. Arje Nachman (703) 696-8427
A basic research program investigating the key enabling technologies necessary to identify space objects that are threats to operations in space and to the earth. Emphasis is on reliable and accurate determination of the trajectory (orbit) of space objects.

High-Energy-Density Propellants

Point of Contact: Dr. Michael Berman (703) 696-7781
A basic research program investigating the key enabling propellant design technologies necessary to support low-cost reliable access to space. Improved rocket propulsion capabilities are required to make space vehicles affordable and to ensure rapid vehicle turnaround. Emphasis is on innovative, practicable approaches to utilize emerging high-energy-density materials that will enhance overall space vehicle capability.

Jam-Proof, Area-Deniable Propagation

Point of Contact: Dr. Jon Sjogren (703) 696-6564
A basic research program investigating the devices, algorithms, and propagation techniques necessary to deny the adversary precision navigation, metrology, and communications while ensuring that this information is available to friendly forces.

Nanosecond Global Clock Accuracy

Point of Contact: Dr. Ralph Kelley (703) 696-8599
A basic research program investigating the use of optical laser frequencies for timing stabilization. One approach is to perform spectroscopy experiments with new intracavity saturation spectroscopy to determine the pressure-broadened sub-Doppler line widths critical for high-precision line locking of lasers (i.e., ultrafrequency accuracy and stability).

Hypervelocity Dynamics

Point of Contact: Dr. Steven Walker (703) 696-6962
A basic research program investigating the key enabling technologies necessary to optimize space vehicle performance. Emphasis is on flight control, flight vehicle, mission status, aerodynamics (energy coupling, modeling, and simulation), aerodynamic and control technologies, and innovative engine and airframe integration (using hypervelocity computational fluid dynamics).

Low-Cost, Lightweight Structures and Materials

Point of Contact: Maj Brian Sanders (703) 696-7259
A basic research program investigating the key enabling technologies necessary to reduce satellite and space vehicle mass by using low-cost, lightweight structures and materials. Emphasis is on enhancing the durability, maintainability, and multifunctionality of lightweight designs for propulsion components, thermal protection systems, cryogenic tanks, and structures.

Power Generation and Storage

Point of Contact: Dr. Harold Weinstock (703) 696-8572
A basic research program investigating the key enabling technologies necessary to provide the power generation and storage required by distributed satellites and space vehicles. Specific technology challenges include (1) high-efficiency, lightweight, low-cost, high-energy-density power generation systems such as high-efficiency solar cells, concentrator arrays, and thermal or solar devices; (2) high-efficiency power management systems; and (3) high-density, lightweight power storage systems such as capacitors, batteries, and high-efficiency flywheels and superconducting magnetic energy storage.

People

Point of Contact: Dr. John F. Tangney, (703) 696-6563

Human-Machine Interface

Point of Contact: Dr. John F. Tangney or Dr. Willard Larkin (703) 696-7793
A basic research program investigating the key enabling technologies necessary to enhance human-machine interfaces. Emphasis is on human factors related to the design of novel interfaces. New

measures of individual cognitive workload will be studied for use in monitoring performance in response to stress and fatigue and for establishing benchmarks for alternative interface systems. Studies of multisensory integration (i.e., auditory, visual, vestibular) will be used to establish standards for development of augmented displays such as virtual reality or helmet-mounted systems. Models of individual real-time knowledge state will be developed to enable technologies of adaptive interfaces and interfaces with embedded training capability. Analysis of system scale performance of operators will be conducted to support modeling and simulation of factors affecting human performance related to interface design.

Team Decision Making

Point of Contact: Dr. John F. Tangney or Dr. Willard Larkin (703) 696-7793
A basic research program investigating the key enabling decision-aiding technologies in support of command and control. Emphasis is on analysis of team performance as a complex decision-making system comprising multiple human and automated agents. This effort takes advantage of synthetic tasks (i.e., laboratory extrapolations of real-world tasks) to identify the strategies used by intelligent agents (which are modeled on human agents) to analyze the stability and robustness of communication patterns in teams faced with increasing flows of information.

Cognitive Engineering

Point of Contact: Dr. John F. Tangney or Dr. Willard Larkin (703) 696-7793
A basic research program investigating design-support technologies. Emphasis is on quantitative measures of human performance in complex tasks such as piloting of air and space vehicles. Cognitive task analysis is used to determine critical points in human performance, and the tasks are embedded in research settings where the sensitivity of human performance to design variants can be quantified.

Submission of New World Vista Proposals

AFOSR is inviting submission of basic research proposals in response to these New World Vistas science and technology needs. Those interested are strongly encouraged to contact the points of contact shown above for additional information prior to submitting proposals specifically directed at these areas. Additional background information may be obtained from the Air Force Scientific Advisory Board's New World Vistas report summary volume. It can be found at the World Wide Web address

http://web.fie.com/htdoc/fed/afr/sab/edu/text/any/afrtnwv.htm

(Web addresses occasionally change. If you cannot find the New World Vistas site at this address, contact AFOSR/PIP at (703) 696-9513 for assistance.) Proposals specifically directed to New World Vistas should be identified as such and should reference the specific New World Vistas area.

III. Research Interests

Aerospace and Materials Sciences

The Directorate of Aerospace and Materials Sciences is responsible for research activities in aerospace, engineering, and materials. The four major projects in the directorate are solid mechanics and structures, structural materials, fluid dynamics, and propulsion. An equally important mission of the directorate is to support multidisciplinary efforts to meet Air Force science and technological needs. The structural materials activities in the directorate and the chemistry activities supported by the Directorate of Chemistry and Life Sciences make an integrated Air Force Office of Scientific Research (AFOSR) structural materials program. The control theory and mathematical modeling research supported by the Directorate of Mathematics and Geosciences complements many structural, fluid mechanics, and propulsion research programs supported by this directorate.

Structural Mechanics

The objective of this research program is to study solid mechanics fundamentals and structural principles that are necessary to ensure the integrity of current and future aerospace structures, including aircraft, missiles, and spacecraft. Proposals are sought that will lead to a fundamental understanding of the behavior of structures that are composed of current metallic materials as well as advanced composite materials. Proposals are also sought that will develop principles to predict nonlinear aerospace structural characteristics under coupled fluid, thermal, and mechanical loads. We are interested in solid mechanics principles that govern nonlinear-coupled deformation and damage mechanisms that dictate anisotropic and heterogeneous medium response and structural performance. Topics such as damage localization, instability formation, homogenization, energy dissipation, and local and global response correlation are of interest. Structural nonlinear behavior and control owing to coupled mechanical, fluid, acoustic, and thermal loads are important to the design and performance prediction of aerospace systems. Fluid-structure interaction, aerothermoelasticity, and the development of intelligent materials and structures are of interest to this program. The degradation of materials and structures over long periods of service is also of interest, since current Air Force weapon systems will remain in service much longer than originally anticipated. This research includes the prediction of material degradation under combined mechanical and environmental loads, as well as the nondestructive detection and quantification of internal damage (e.g., corrosion, fatigue cracking).

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Mechanics of Composite Materials

Research in this program seeks to establish the fundamental understanding required to design, process, and predict thermomechanical performance of aerospace structural material systems. Projected Air Force applications will require multifunctional material systems capable of sustained performance in extreme loading environments. Candidate structural material systems are almost all highly heterogeneous, composite media. These systems include metallic and intermetallic alloys, advanced composite material systems (including polymer-matrix, metal-matrix, ceramic-matrix, and carbon-carbon composites), and solid rocket propellants and liners. Innovative new material systems, such as nanostructural materials and functionally graded materials, are also of interest.

The continued development of safer, more durable aerospace vehicles with improved performance characteristics depends on researchers' ability to understand, characterize, and quantitatively model the expected behavior of such emerging material systems. Therefore, this program focuses on developing and applying appropriate mechanics principles and methodology to treating advanced materials at multiple scales. Particular emphasis is placed on material systems that are capable of operating in extreme-temperature environments, such as those to be used in future engine and airframe component designs. Quantitative connections between evolving microstructural features and resulting performance parameters must be established, along with an analytical understanding of the relationship between processing and microstructure. Interdisciplinary approaches with an integrated analytical-experimented foundation that include mechanics, materials science, chemistry, physics, and applied mathematics are encouraged. Interaction with Air Force laboratory researchers who are conducting basic research is also encouraged, as is interaction with Air Force personnel in exploratory and advanced development programs.

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Unsteady Aerodynamics and Hypersonics

Recent Air Force technology studies have identified essentially four capabilities that are necessary for future US air superiority. These are global reach/power, rapid response (speed), low casualty rates, and space operations. Two flight vehicle concepts directly result from the above desired capabilities: the unmanned air vehicle and the hypersonic cruise vehicle. The unsteady aerodynamics and hypersonics research program within the Aerospace and Materials Directorate is focused on providing the fundamental fluid mechanics research base for these future systems. Through a balance of experiments, analytical modeling approaches, and numerical simulations of the relevant flow physics, a fundamental understanding of the basic fluid flow fields associated with future complex configurations is achieved. This increased knowledge base will provide flow field prediction methods and flow control approaches that, in the short-term, will reduce the weight and cost of future systems, and in the long-term, will enable completely new, revolutionary vehicle designs which are unacceptable today due to aerodynamic performance constraints.

Unsteady aerodynamics is a key element in the development and optimization of future Air Force weapon systems. Unmanned air vehicles will incorporate highly offset inlet diffusers, three-dimensional nozzle configurations, swept leading and trailing edges, and internal weapons bays; configuration attributes that lead to highly separated, time-dependent flows. Because these systems are unmanned, they can maneuver at extremely high rates, producing very dynamic forces on the aircraft body. Thus, research areas of interest include understanding the basic mechanisms present in time-dependent aerodynamic flows of all types, separated flows, separation control, circulation control, and vortical flows. Low-order flow modeling approaches that lead to adaptive control methods are desired. Internal and external flow tailoring for aerodynamic shape change is of interest. Nonlinear aero-structure interaction research, including flow control approaches for suppression of destructive flow-structure interactions, is also of interest. Aero-acoustics research, especially as it applies to airframe noise or sonic fatigue, would also be considered a part of the aero-structure interaction subthrust.

Hypersonic aerodynamics research is critical to the Air Force's renewed interest in space operations. The size and weight of a hypersonic vehicle, and thus its flight trajectory and required propulsion system, are in large part determined by aerodynamic considerations such as boundary layer transition, shock-boundary layer interactions, drag, and airframe propulsion integration. A major research area of interest is high-speed boundary layers. Quiet wind tunnel research, cross-flow instability mechanisms, and the receptivity of high speed boundary layers to external disturbances are all areas of interest. Weakly-ionized flows used for high-speed vehicle drag reduction are of interest as well as secondary jet injection for high speed flight control. Finally, the fundamental flow physics associated with the airframe integration of combined cycle propulsion systems of all types (ramjet, scramjet, PDEs) is of interest, particularly the time-dependent characteristics of the inlet and nozzle flow fields.

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Turbulence and Rotating Flows

Research in turbulence and internal flows is primarily motivated by Air Force requirements for airbreathing propulsion systems and advanced flight controls. In this context, the program seeks to advance fundamental understanding of the complex, unsteady flows occurring in gas turbine engines, and to apply that understanding to the development of physically based predictive models and innovative concepts for controlling complex internal flows.

Research that addresses fundamental flow phenomena occurring in gas turbine engines, emphasizing the roles of unsteadiness and three-dimensionality in determining the performance, stability, and heat-transfer characteristics of these internal flows, is encouraged. Active control strategies for rotating stall and surge instabilities in gas turbine engine compressors are of interest. Of particular concern is the phenomenon of unsteady flow-induced forced blade response and its impact on high-cycle fatigue of turbine engine components. Another principal concern is the prediction and control of heat transfer in gas turbines, including the effectiveness of both film-cooling and internal-cooling flows. Other areas of interest include blade wake effects, shock impingement effects, high free-stream turbulence, stagnation-point heating, blade tip clearance flows, blade hub juncture flows, and transition heat transfer phenomena.

The program also addresses a broader class of flow control and turbulence problems related to technologies such as fluid thrust vectoring, internal flow tailoring, high lift, enhanced jet mixing, signature reduction, aero-optics, aeroacoustics, and drag reduction. Turbulent flows relating to space applications are also of interest.

Primary emphasis is placed on understanding and controlling fundamental flow processes using active flow control approaches, including the exploration of microelectromechanical systems (MEMS) technology for aerodynamic measurement and control. A particular challenge is the exploration of innovative actuator concepts for fluids-based flow and flight control strategies. We are also interested in ideas exploring frontiers in fluid mechanics relative to fundamental flow processes occurring in microscale devices.

Research contributing to the understanding of flow instabilities and the mechanisms of transition from laminar to turbulent flow in both bounded and free-shear flows is of interest--especially the receptivity of linear and nonlinear transition processes to background and imposed flow disturbances--as is the impact on flow controllability. Improved turbulence modeling approaches are sought for the prediction of flow and heat transfer in highly strained and unsteady turbulent environments (e.g., gas turbine engines). In this context, we seek original ideas for modeling turbulent transport, especially ideas for incorporating the physics of turbulence into predictive models. We are also interested in improved subgrid models for LES methods, especially in the near-wall region. High quality turbulent flow data relevant to the advancement of transport and subgrid models for high-Reynolds number turbulent flows are also of interest.

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Combustion and Diagnostics

Fundamental understanding of the physics and chemistry of multiphase, turbulent reacting flows is essential to improving the performance of chemical propulsion systems, including gas turbines, ramjets, scramjets pulsed detonation engines, and chemical rockets. We are interested in innovative research proposals that use simplified configurations for experimental and theoretical investigations.

Our highest priorities are studies of supersonic combustion, atomization and spray behavior, fuel combustion chemistry, supercritical fuel behavior in precombustion and combustion environments, and novel diagnostic methods for experimental measurements. Other topics of interest include turbulent combustion, soot formation, and interactive control.

In addition to achieving fundamental understanding, we also seek innovative approaches to produce reduced models of turbulent combustion. These models would improve upon current capability by producing prediction methods that are both quantitatively accurate and computationally tractable. They would address all aspects of multiphase turbulent reacting flow, including such challenging objectives as predicting the concentrations of trace pollutant and signature producing species as products of combustion. Approaches such as novel subgrid-scale models for application to large eddy simulations of subsonic and supersonic combustion are of interest.

Research in supersonic combustion relates to the Air Force New World Vistas Hypersonics science and technology subarea, as described elsewhere in this booklet. proposals addressing this topic should refer to New World Vistas.

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Space Power and Propulsion

Wide-area surveillance and space-based defense require affordable, on-demand, on-schedule launch and orbit transfer vehicles as well as accurate plume prediction models.

Research activities fall into three areas: nonchemical orbit-raising propulsion, chemical propulsion, and plume signatures/contamination resulting from both chemical and nonchemical propulsion. Research in the first area is directed primarily at advanced space propulsion, and is stimulated by the need to transfer payloads between orbits, station-keeping, and pointing. It includes studies of the sources of physical (nonchemical) energy and the mechanisms of release. Our emphasis is on understanding electrically conductive flowing gases (plasmas) that serve to convert beamed or electrical energy into kinetic form. Theoretical and experimental investigations are being conducted on the phenomenon of energy coupling and the transfer of plasma flows in electrode and electrodeless systems under plasma dynamic environments.

Topics of interest include characteristics of pulsed and steady-state plasmas; scaling physics; characteristics of equilibrium and non-equilibrium flowing plasma; characteristics of electrical and hydrodynamic flows; instabilities of plasma bulk and wall layers; interactions of plasma-surface,-electrode,-magnetic, and-electric fields; losses to inert parts; characteristics of plasmas in high-magnetic fields and pressures; and plasma diagnostics (new and unique non-interfering measuring techniques).

Research is being conducted on chemical propulsion to predict and suppress combustion instabilities in solid and liquid rocket systems. Topics of interest include the modeling of the coupling among unsteady flows, combustion, acoustic fields, and chemical kinetics.

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Metallic Materials

The goal of research in metallic materials is to provide the fundamental knowledge required to develop metallic alloys for aerospace applications. Potential applications of these materials include turbine engines, rocket propulsion, airframe and spacecraft structures, and hypersonic vehicle systems. Research on improved metallic structural performance capable of low-cost operating and sustaining is encouraged. Research on new actuation/sensing alloys that advanced the integrated system characteristics is also of interest.

This goal will be accomplished by understanding the relationships between processing, chemistry, and structure on the one hand and properties of metallic and metallic composite materials on the other. Specific scientific topics include the development and experimental verification of theoretical and computational (atomistic) models, processing science, phase transformations, interfacial phenomena, strengthening mechanisms, plasticity, creep, fatigue, environmental effects, and fracture of structural metallic materials. Materials currently under research include lightweight structural metals, refractory metals, intermetallic alloys, amorphous alloys and their composites, shape-memory alloys and microlaminated materials.

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Ceramics and Nonmetallic Materials

The objective of this research program is to provide scientific background for current and future Air Force-related applications of ceramics, ceramic-matrix composites (CMCs), and carbon-based composites. One major component of this objective is to increase our understanding of high-temperature strength and creep resistance of ceramic materials at the atomic and microscopic levels. This basic knowledge is necessary to develop reliable, creep-resistant, and affordable ceramics for high-temperature structural applications that will improve propulsion and vehicle performance. Of particular interest are creep-resistant oxide materials (e.g., yttrium aluminum garnet, alumina, and zirconia). In addition, silicon nitride, silicon carbide, and other refractory nonoxide ceramics are being investigated for very high temperature applications.

One of the major detriments to using ceramics for structural applications is their brittleness. This program addresses how to reduce or control the brittleness of ceramics in three ways: (1) by studying the fracture, fatigue, and reliability of ceramics, thereby providing criteria for predicting their performance under a variety of conditions; (2) by evaluating transformation toughening, flaw- and stress-induced toughening, and other techniques of increasing toughness; and (3) by designing, fabricating, and evaluating fiber, laminate, and particulate CMCs that fracture in a metal-like, "graceful" manner. It is expected that fiber-reinforced CMCs will satisfy requirements for tough, reliable materials capable of prolonged operation at and above 2,700 degrees Fahrenheit (1,500 degrees Celsius). To meet these goals, this program emphasizes research efforts on oxidation-resistant, thermally-stable fiber-matrix interfaces, optimization of strength of fiber-matrix interfaces, and novel processing techniques that improve the performance and affordability of CMCs.

Lightweight, high-temperature-resistant carbon-carbon composites are increasingly used as structural elements for hypersonic aircraft and space structures. To facilitate their use, these materials' resistance to oxidation must be improved. Thus this program seeks to elucidate oxidation mechanisms of carbon materials, with the goal of inhibiting oxidation. In addition, new approaches to oxidation-inhibiting coatings for carbon-carbon composites are being sought.

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Organic Matrix Composites

This program addresses the materials science issues relating to the use of polymer matrix fiber reinforced composites and related material technologies in aerospace and space structures such as airframes, engine components, rocket, launch vehicles and satellites. The goal is to provide the science and knowledge base that will lead to higher performance, more durable, more affordable structures for Air Force applications. This task is consistent with the future global mobility and space operations capabilities outlined in New World Vistas. The approach is to address issues relating to the development of improved performance or lower cost polymer-matrix composite (PMC) systems and the processing and the utilization of these structures during deployment. Chemistry and processing of structural adhesives and polymeric precursors for ceramic and carbon-carbon structures are also within the scope of this program. Materials issues relating to all material preforms and processing leading to the end components are of interest. Examples of these include resin chemistry and formulations, prepregs processing, dry preforms, lay-up operation and cure processes.

The emphasis of the current program is to study the environmental effects on the long-term properties of polymer matrix composites. These environmental effects include harsh processing environments (e.g., high-temperature processing), application environments (e.g., high-temperature exposure under pressurized conditions), and service environments (e.g., moisture, solvents). Research will address the chemistry and physics of the degradation mechanisms that lead to deterioration of the performance of the PMC structures. The scope will cover the matrix, reinforcement, interphase, and composite as a whole. The results of this research will lead to accurate prediction of PMC structures' service life and to alternative material systems, processing procedures, and service practices that can increase the service life of these structures.

Current research supports include high performance adhesive and pre-damage nondestructive evaluation of adhesive bonded structures. High-temperature and/or low-shrinkage adhesives are needed to improve performance of high-temperature components and adhesive-bonded joints. New nondestructive evaluation methods that will probe chemical bonding integrity instead of macroscopic damage are of interest.

Innovative material concepts that will lead to higher temperature and more damage-tolerant composites, lower cost processing and fabrication, and improved materials for space operation and launch vehicle are also of interest.

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Physics and Electronics

Research in physics and electronics generates the fundamental knowledge needed to advance Air Force operational capabilities in directed energy weapons; surveillance; stealth; electronic countermeasures; guidance and control; information and signal processing; and communications, command, and control. The program is of substantial breadth, extending from plasma and quantum physics, to the understanding of the performance of novel electronic devices, to maintaining device integrity in the harsh environment of space, to engineering issues such as those found in microwave or photonic systems or materials-processing techniques. One main objective of the program is to balance innovative science and Air Force relevance, the first element being forward looking and the second being dependent on the current state of the art. This directorate takes particular pride in the strong synergistic ties it has forged between university researchers and those in our Air Force Laboratory community. Research areas of interest to the Air Force Program managers are described in detail in the subareas below.

Plasma Physics

We are seeking innovative approaches for exploring novel concepts that exploit the collective interactions of charged particles with electromagnetic fields. Our primary areas of interest encompass novel concepts for the electron-beam-driven generation of high-power microwave and millimeter-wave radiation, a better understanding of microwave interactions with collision-dominated sparse plasmas, and power efficient methods to generate and maintain significant free-electron densities in sea-level air.

The high power microwave (HPM) research to be sponsored will be closely linked to the ongoing DoD Multidisciplinary Research Initiative (MURI)2 program on this topic as well as to active HPM efforts underway at Air Force and other defense laboratories and to relevant portions of New World Vistas. These efforts look to primary applications in future directed energy weapons and electronics countermeasure systems. Possible applications for large area surveillance systems are also of interest. The overall HPM program draws particular strength from a close working relationship to the Naval Research Laboratory's Tri-Service Vacuum Electronics Initiative and to the vacuum industrial research community.

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2 The MURI is a Department of Defense (DOD) initiative to enhance universities' capabilities to perform research and related education in science and engineering areas critical to national defense. The MURI supports research teams whose efforts intersect more than one traditional science and engineering discipline.

The initiation in the Spring of 1997 of the DoD Air Plasma Ramparts MURI program has focused increased interest on the search for novel methods to reduce the prohibitive power budget currently required to generate and maintain appreciable free electron populations in the open atmosphere. New ideas are sought to attack this difficult problem.

Of course, fresh ideas for completely new plasma research areas are always of interest as long as Air Force Relevance can be postulated. Therefore, other proposed plasma research topics will be considered on a case by case basis. However in general, this program is not interested in dense (strongly coupled) plasmas, fusion plasmas, or space plasmas, since those topics are already heavily funded by other agencies.

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Space Electronics

This research program addresses Air Force requirements for advanced high performance electronic devices. Depending upon the specific requirement, this calls for high efficiency, greater speed, higher power, lower noise, low voltage/low power performance and so forth. [It is useful for the proposer to learn of these Air Force needs and to point out how the ideas being put forward would address them].

There is greater emphasis given to analog devices than to digital and optoelectronic structures. (These are covered in programs elsewhere at AFOSR). Emphasis is shifting away from more 'traditional' compound semiconductor materials, such as GaAs and InP, to emerging materials such as the wide bandgap GaN family. There is also interest in the understanding and electronic applications of so-called 'wet Al-oxides' formed by the oxidation of AlAs and related materials. The effects of radiation (natural and man made) on these and other electronic devices are important concerns.

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Atomic and Molecular Physics

This program involves experimental and theoretical research on the properties and interactions of atoms and molecules and forms the basic underpinning of a large range of technological applications in navigation, guidance, communications, atmospheric physics, low-and high-altitude nuclear weapons, effects phenomenology, directed-energy weaponry, and lasing mechanisms. Topics to be pursued include the following:

1. Trapping and cooling atoms and ions for high-resolution spectroscopy, studying cold-atom collisions, and developing advanced frequency standards.

2. Studying ultraviolet emission cross sections of atmospheric species by electron impact.

3. Observing interactions of atoms in strong electric, magnetic, and radiation fields.

4. Developing atomic physics fundamental to understanding plasma-enhanced deposition and microetching processes.

5. Understanding antiproton capture, confinement, transport, injection, and annihilation processes.

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Imaging Physics

This program investigates fundamental issues in imaging physics. These include issues concerning the image formation and propagation processes. Physical and mathematical problems in inversion/reconstruction and inverse scattering, as well as electromagnetic wave generation/propagation in various media, are central to this topic. New ways of representing object fields with a class of basis functions broader than sines and cosines and propagating these fields to distant planes can lead to advances in feature extraction and secure communications. Theoretical foundations for imaging diversity methods (e.g., wavelength diversity, phase diversity, polarization diversity) are of interest.

Multi-hyperspectral techniques, data/sensor fusion, and smart sensors are being investigated. The focus of these three areas is to evaluate the advantages of on-chip and on-sensor processing for space-based and ground-based systems, as well as electronic mimicking of biological vision systems. The goal is to provide real-time information to the battlefield commander rather than raw data. Advances in image compression, integrated hardware and software parallelization, real-time response, and adaptive imaging controllers (e.g., neural networks) are sought for both ground-based and space-based sensing systems.

Unconventional imaging methods are being developed to provide novel active (artificially illuminated) and passive (naturally illuminated) imaging and target recognition capabilities for war combatants. Initial unconventional imaging methods research will concentrate on synthetic aperture techniques, information recognition and extraction, and multiresolution imaging of and from space-based assets.

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Optoelectronic Information Processing: Devices and Systems

This program includes investigations in two affiliated areas: (1) the development of optoelectronic devices and supportive materials, and (2) the insertion of these components into optoelectronic computational and information-processing systems. Device exploration and architectural development for processors are coordinated; synergistic interaction of these areas is expected, both in structuring architectural designs to reflect advancing device capabilities and in focusing device enhancements according to system needs.

Research in optical materials and optoelectronic devices emphasizes the insertion of optical technologies into computing, image-processing, and signal-processing systems. To this end, this program continues to foster surface-normal interconnection capabilities, combining arrays of sources or modulators with arrays of detectors, with both being coupled to local electronic processors, often in "smart pixel" configurations.

A related program thrust explores optical memory technologies that support page-oriented or holographic configurations. Capabilities of persistent spectral hole-burning systems for memory, as well as for processing, anchor this thrust. The spatiospectral attributes of this technology link "free-space" interconnect concepts to those of multispectral systems. Devices are being developed that emit, modulate, transmit, filter, switch, and detect multispectral signals, for both parallel interconnects and quasi-serial transmission.

Understanding the fundamental limits of the interaction of light with matter is important for achieving these device characteristics. Semiconductor materials and structures are the basis for the smart pixel technologies. In homogeneously broadened, generally cryogenic, optically resonant materials support the memory development. General themes for acceptable device approaches include high-bandwidth interface, low-energy consumption, demonstrable parallel access, and gain, logic, or memory attributes with prospects for array configurations.

System-level investigations incorporate these devices into processing architectures that exploit their demonstrated and envisioned attributes and determine appropriate problem classes for optical and optoelectronic approaches. The computational advantages and proper use of parallelism provided by optical implementations continue to guide architecture development. For example, the implementation of parallel compression and forward error correction techniques for storage or transmission of imagery is a current thrust. Computer interconnections continue to encounter increasing difficulty in signal transmission constrained by wire-crossing layout restrictions, electromagnetic interference, and cross-talk--impediments that may be circumvented by optical interconnect approaches. Illustrative is the time-honored Von Neumann bottleneck in memory-to-processor data transfers; parallel access capability promised by optical technology may ameliorate this constriction. Alternatively, a second program thrust emphasizes the use of the inherent, extremely high bandwidth of optical carriers by investigating systems that use multispectral data representations. Presently this thrust focuses on the incorporation of multispectral devices into transmission routing nodes to decrease latency and manage contention. Based on this prototypical application, future systems may satisfy computational functionalities.

One architectural problem currently being investigated is optical access and storage in memory devices to obviate capacity, access latency, and input/output bandwidth concerns. Another focus is on spectral domain processing to perform terabit-per-second multiplexing as well as data packet routing and byte-parallel transmission.
This program supports Air Force requirements for information dominance by increasing capabilities in image capture; processing, storage, and transmission for surveillance; target discrimination; and autonomous navigation. In addition, high-bandwidth interconnects enhance performance of distributed processor computations that provide real-time simulation, visualization, and battle management environments.

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Laser and Optical Physics

Laser and Optical Physics research explores new ideas, knowledge, and insights in selected aspects of these areas. Novel lasers and laser arrays, as well as nonlinear optical devices and phenomena are of interest. Ultrafast optoelectronic techniques are being investigated with the hope of dramatically advancing the speeds and available power of electronic circuits. Picosecond and femtosecond optical pulses are being studied to generate very wide band signals, as well as to control and test electronic systems at frequencies into the millimeter-wave range. Optical interconnect techniques are being investigated for application to millimeter-wave circuits. These could significantly contribute to wide-band and impulse radar systems. Very wide band, mode-locked lasers are being devised and investigated as important devices in their own right, as well as for practical implementations of the ultra-high-speed electronic studies. Semiconductor laser arrays are being intensively investigated, together with associated optics, in the mid-infrared, in support of ongoing important Air Force development programs. Directed energy beams, particularly laser beams, are being explored in direct-write materials-processing techniques that offer broad and extremely important new capabilities, particularly in microelectronics and micromechanics fabrication and packaging. Adaptive optical devices and techniques are of interest, including large and micro-optical adaptive mirrors and mirror arrays. Studies pertaining to high-resolution optics in space are of interest.

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Quantum Electronic Solids

This program focuses on materials that exhibit cooperative quantum electronic behavior, with the primary emphasis on superconductors--and any conducting materials with surfaces that can be modified and observed through the use of scanning tunneling--and related atomic-force microscopies. The program also focuses on device concepts using these materials for electromagnetic detection and signal processing in Air Force systems.

The long-standing materials aspects of the program are based on the fabrication, characterization, and electronic behavior of superconducting thin films, which ultimately can lead to the discovery of new and improved electronic circuit elements. Two main objectives are to understand the mechanisms that give rise to superconductivity in selected ceramics and to produce high-quality Josephson tunneling structures. Recently the program has been expanded to include bulk superconducting materials that can be useful in producing current-carrying wires in power applications. A continuing interest in this program is the search for new electronic device concepts that involve superconductive elements, either alone or in concert with semiconductors and normal metals; there is also interest in understanding high-power absorption in high-temperature superconducting materials at microwave frequencies.

A minor aspect of this program is the inclusion of scanning probe techniques to fabricate, characterize, and manipulate atomic-, molecular-, and nanometer-scale structures, with the goal of producing a new generation of improved sensors, resulting in the ultimate miniaturization of analog and digital circuitry.

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Semiconductor Materials

This research area is directed toward developing advanced optoelectronic and electronic materials and structures to provide improvements required for future Air Force systems. The focus is currently on growth and use of semiconductors in bulk structures, single heterostructures, quantum wells, and quantum dots. Proposals are sought for significant advances in these areas, or expansion to novel application of materials such as organic polymers, amorphous and polycrystalline materials, with estimates of potential improvements compared to present capabilities, and the impact on Air Force capabilities. Wavelength ranges of interest span the spectrum from UV to IR.

Novel fabrication methods, in-situ and ex-situ characterization methods, and innovative substrates and materials will provide the driving force behind advances in these areas. Growth methods that increase the integration density, or fill factor and efficiency are of significant interest, as are device structures that integrate cooling, or exploit designs that avoid heating. Nonlinear optics is another area of interest for increasing laser power at desired wavelengths, and protection from directed energy threats. Advanced optoelectronic and electronic materials will provide the building blocks for advances in laser and sensor applications and related components.

Compound semiconductors, heterostructures and other such materials are the foundation of new generations of wavelength-diverse, high sensitivity detectors, and lower power consumption, high-efficiency electric lasers. These materials provide the properties necessary for improved space situational awareness, NMD/TMD capabilities, and space asset protection to support Space Control, and theater missile surveillance, threat warning and tracking, chemical and biological agent detection, improved satellite communications and environmental monitoring as part of Space Force Enhancement.

Innovative approaches are sought for lasers to provide, or advance, capabilities such as aircraft infrared countermeasures, laser communications, laser radar for precision guided munitions, illumination, chemical agent detection, missile warning sensor jamming, and laser array pumping.

Innovative approaches are sought for sensors for applications such as target and background phenomenology characterization, threat identification, warning, and tracking, and protection of aerospace vehicles from electro-optic, infrared guided threats. Materials are needed to provide survivability to aircrews, sensor systems, aircraft, and space systems from directed energy threats.

This research interest supports the Space Superiority, and Precision Strike integrated technology thrusts, and Space Vehicles, Directed Energy, Sensors, and Materials and Manufacturing enabling technology areas as detailed in the Air Force Science and Technology Plan.

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Electromagnetic Materials

Air Force optoelectronic signal processing, communications, surveillance, and optical warfare systems require continual improvements in performance. This research project is directed toward developing advanced optoelectronic materials to provide those required improvements in future Air Force systems, thereby enhancing the effectiveness of tomorrow's warfighters. In particular, we seek to generate the fundamental knowledge required for the growth and use of novel, as well as existing, optoelectronic materials and structures. No single material has the combination of properties required for all applications, so several classes of single-crystal semiconductors--including a variety of heterostructure combinations--are currently under investigation. Similarly, quantum-well semiconductor heterostructures for electro-optical and nonlinear-optical materials are also being studied.

Compound semiconductors and heterostructure combinations of such materials are the foundation of new generations of wavelength-diverse, highly efficient optoelectronics, and highly sensitive, frequency-agile electro-optics. These materials provide the properties necessary for advanced surveillance applications, and optoelectronic communication systems for a future command and control infrastructure. We are currently investigating compound semiconductors for use in detectors that will operate in the far-infrared spectral range, multispectral infrared detectors, lasers for infrared spectroscopic uses, and optoelectronics for active countermeasures in the infrared spectrum. Materials are being pursued primarily in III-V semiconductors, with emphasis on atypical compounds and expansion to the extremes of the periodic table.

Our overall emphasis is to combine materials science with solid-state physics to investigate the fundamental aspects of growth, defects, and physical properties of multilayer semiconductor structures. This will form the basis of an ability to engineer the energy band structure of semiconductors to achieve high-performance optoelectronic and electro-optical devices. Opportunities remain to be explored in the areas described above.

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Chemistry and Life Sciences

A wide range of fundamental chemistry and life sciences research is supported to provide the Air Force with novel options to increase performance and operational flexibility. The chemistry effort in the directorate supports the structural materials activities in the Directorate of Aerospace and Materials Sciences to make an integrated AFOSR structural materials program. Although the program descriptions that follow are specific subareas of interest, we are also interested in exploring novel ideas that bridge the disciplines. The interfaces between biology and chemistry, biology and physics, psychology and physics, or biology and behavior often provide the insights necessary for technological advances. We encourage your creativity in suggesting novel scientific approaches for our consideration.

Polymer Chemistry

The goal of this research area is to gain a better understanding of the influence of chemical structures and processing conditions on the properties and behaviors of polymeric and organic materials. This understanding will lead to development of advanced polymeric materials for Air Force applications. Our approach is to study the chemistry and physics of these materials through synthesis, processing, and characterization. This area addresses both functional properties and properties pertinent to structural applications. Materials with these properties will provide capabilities for future Air Force systems to achieving global awareness, global mobility, and space operations as envisioned in New World Vistas.

Proposals with innovative material concepts that will extend our understanding of the structure-property relationship of these materials and achieve significant property improvement over current state-of-the-art materials are sought. Our current interests include photonic polymers, polymers with interesting electronic properties, liquid crystals and liquid crystalline polymers, and durable coatings for aircraft and nanostructures.

In the area of photonic polymers, research emphases are placed on electro-optic and photorefractive polymers. It is desirable to increase the electro-optical coefficients of organic and polymeric materials with appropriate levels of thermal and temporal stability. Space operation issues of these polymers are also of interests. Control of speed and wavelength sensitivity in organic photorefractive polymers is currently supported. Examples of electronic properties of interest include conductivity, electrochromaticism, electroluminescence and electro-pumped lasing. In the area of structural properties, polymers with high thermomechanical properties are desirable. End uses of these structural polymers include aircraft and rocket components, canopies, coatings, and space structures. Issues relating to impact toughness and lifetime durability will be of special interest. Current supports in nanostructures include controlling optical, electronic and mechanical properties and fabrication of submicron scale structures.

Material concepts that can improve on the above-mentioned optical, electronic, and mechanical properties of polymers are sought. These concepts include, but are not limited to, polymer blends, liquid crystals and liquid crystalline polymers, and nanostructures.

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Surface Science

Surface science supports basic research in chemistry on the interface, reactivity, and analysis of surfaces and thin films. Our goal is to improve our understanding of surface processes involved in these areas. Research in the chemistry and morphology at interfaces will lead to a better understanding of the mechanisms involved in those surface processes, which in turn will lead to more effective modification and control of surface relationships.

Research in surface chemistry, tribochemistry, electrochemistry, and chemical sensors will study basic chemical phenomena at the interface, such as nucleation and growth of thin films and alloys (not to include semiconductors), friction and wear, lubrication, corrosion and materials degradation, compact power sources, and electrochemically induced reaction products and kinetics. Work supported by this program includes chemical sensing of corrosion and wastes at the interfaces/surfaces of aircraft and their servicing environment. This may lead to development of diagnostic tools that will alert technicians to aircraft areas that may experience corrosion or wastes produced in their service area, thus helping to monitor and prevent these problems. This also includes a program, which looks at the mechanism of the corrosion of aluminum alloys and prevention of that corrosion.

Our other work involves the solid, liquid, and vapor states of the tribochemistry program and is designed to provide the Air Force with improved novel lubricants, lubrication systems, and wear-resistant coatings for current-and future-generation aircraft engines. The electrochemistry program is interested in molten salt systems for compact power sources and new alloy systems for a variety of Air Force systems. Finally, the surface chemistry program is interested in thin magnetic and alloy film growth kinetics and mechanisms at the surface to understand structure property relationships for future materials needs.

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Theoretical Chemistry

The objectives of the theoretical chemistry program are to develop and apply predictive tools for designing new materials and improving processes important to the Air Force. Areas of interest include the structure and stability of molecular systems that can be used as advanced propellants; methods to calculate the NLO properties of materials; determining, predicting, and modeling the atomic interactions at interfaces that affect wear and lubrication and that control deposition and growth of nanostructures on surfaces; calculating properties of bulk materials from atomistic considerations; and using theory to describe and predict the details of ion-molecule reactions relevant to ionospheric and space effects on Air Force systems.

Interest in advanced propellants is concentrated in the High Energy Density Matter (HEDM) which aims to develop new propellant systems to allow double the current payload capacity to be put into orbit. Theoretical chemistry is used to predict promising energetic systems, to assess their stability, and to guide the efficient synthesis of selected candidates. Current emphasis is on developing theoretical tools that can be used to help guide the synthesis of HEDM candidates. These tools will help identify the most promising synthetic reaction pathways and predict the effects of solvation and other many-body and media effects on synthesis. We also are seeking to identify novel energetic molecules and investigating the interactions that control or limit the energy that can be stored by energetic dopants in cryogenic solids.

Research on metals and ceramic materials emphasizes clusters, nanophase materials, and the structure, stability, and growth of metal/ceramic interfaces. We also encourage the development of new methods and algorithms that take advantage of parallel computing architectures to predict properties with chemical accuracy for systems having a very large number of atoms.

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Molecular Dynamics

The objectives of the molecular dynamics program are to understand, predict, and control the reactivity and flow of energy in molecules. This knowledge will be used in atmospheric chemistry to improve our detection and control of signatures; in high-energy-density material research to develop new energetic materials for propellants and propulsion systems; in chemical laser research to develop new high-energy laser systems; and in many other chemical systems in which predictive capabilities and control of chemical reactivity and energy flow at a detailed molecular level will be of importance.

Areas of interest in atmospheric chemistry include the dynamics of ion-molecule reactions relevant to processes in weakly ionized plasmas, atmospheric heterogeneous chemistry in aircraft and rocket exhausts, gas-surface interactions in space, and reactive and energy transfer processes that produce and effect radiant emissions in the upper atmosphere. Research on high energy density matter for propulsion applications investigates novel concepts for storing chemical energy in low-molecular-weight systems, the stability and sensitivity of energetic molecular systems, and the storage of energetic species in cryogenic solids. Research in energy transfer and energy storage in metastable states of molecules supports our interest in new concepts for chemical lasers.

Materials related research includes the study of the synthesis, structure and properties of metal-containing molecular clusters. Also of interest is the study of the structure, stability, and growth of metal/ceramic interfaces. Fundamental studies aimed at developing basic understanding and predictive capabilities for chemical reactivity, bonding, and energy transfer processes are also encouraged.

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Chronobiology and Neural Adaptation

This program supports basic research on the circadian timing system--the biology underlying fatigue--including individual differences and performance prediction, the brain processes involved in regulating adaptation to changes in state, from sleep to waking to arousal. Current experimental approaches include primarily human behavioral studies.

The focus of the chronobiology portion of the program is to elucidate biological mechanisms responsible for circadian rhythmicity and how these mechanisms influence behavior relevant to skilled human performance. Current efforts investigate circadian and sleep/wake dynamics, monitoring key aspects of waking neurobehavioral functions; basic researchers work with industry partners representing a range of potential solutions, based on delivery systems, that can be updated from new research findings.

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Perception and Cognition

This program supports research on high-order aspects of human information processing that contribute to skilled human performance. The overall objective is quantitative modeling of ways that humans process information to learn, to recognize and assess events in dynamic environments, and to make decisions. Specific objectives include, but are not limited to quantitative models and new research methods that will enable progress in understanding (a) multisensory perceptual integration, (b) cognitive and perceptual factors in the acquisition of complex skills, including motor skills, (c) quantitative assessment and identification of individual attributes that determine or constrain human performance, especially in complex information-processing environments, and (d) fundamental constraints of attention and memory on human performance. The study of these topics in conditions that involve high workloads, sustained operations, stress, or fatigue is encouraged. Multidisciplinary approaches are also encouraged, especially if useful in the development of quantitative models of these human performance issues.

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Sensory Systems

The Sensory Systems Program is a multidisciplinary research program designed to develop a better understanding of dynamic input into human visual, auditory, and vestibular systems. One new area of interest is identifying biological materials that may enhance human visual, auditory, or vestibular system processes. In general, this program supports research on sensing systems of interest to the Air Force, with emphasis in two areas:

a. Research in visual, auditory, and vestibular senses coupled with multisensory and sensorimotor integrative mechanisms--This effort encourages theoretical and experimental approaches involving psychophysics and psychoacoustics. It is encouraged that basic research in these areas be carried out in concert with in-house research efforts at Air Force laboratories located at Brooks Air Force Base, Texas and Wright-Patterson Air Force Base, Ohio.

b. Identification of biological systems that act as detectors or sensors for the purpose of enhancing visual, auditory, recognition processes--This new research area is designed to determine a biological material's fundamental physical properties and how those properties may be incorporated into existing detection devices or act alone. Researchers from the fields of theoretical and experimental biophysics, bioengineering, biology, biochemistry, and physiology, integrated with classical materials science, are encouraged to work in concert with in-house scientists at the Air Force laboratories at Wright-Patterson Air Force Base, Ohio.

The goal of the Sensory Systems Program is improving our understanding of sensing mechanisms to help improve human performance as well as to develop machine sensors with the exquisite sensitivity and specificity of biological sensory systems.

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Toxic Biological Interactions

Air Force operations utilize physical and chemical agents that may interact with biological tissue and be potentially harmful to military and civilian personnel, to the surrounding populace, and to the environment. The agents include non-ionizing radiant energies (radio frequency radiation, microwaves and laser light), heavy metals (chromium and cadmium), and various chemicals that constitute fuels, propellants and lubricants of interest to the Air Force. Exposure to these agents may result directly from their use during Air Force operations and maintenance and, in the case of chemicals, may also occur indirectly as a result of leaky storage containers, for example, that contaminate waste streams, ground water and soil. To protect humans and maintain safe working environments, the Air Force supports basic research that endeavors to understand how these agents may interact with biological systems at the subcellular and molecular levels to produce toxic effects. The Air Force also supports studies that explore novel experimental and computational techniques for use in assessing the potential health risks of these agents. Because the Air force continually advances technologies that may depend on the use of new chemicals and unique modes of radiant energy, it has become necessary to develop reliable, rapid and inexpensive methods for estimating health risks due to exposure. Mechanistically based in vitro biomarkers combined with computational toxicology/chemistry have been identified as research areas that may be of special importance in achieving our goals. Supporting this kind of research is also in harmony with our goals to minimize the use of animals in research and to facilitate the development of safe alternatives for environmentally hazardous materials and manufacturing processes. To accomplish these goals, the program in Toxic Biological Interactions supports toxicology-related research that investigates the interactions of biological systems with non-ionizing radiation and chemicals of interest to the Air Force.

The following represent some basic research interests of the Air Force in Toxic Biological Interactions:

I. CHEMICAL TOXICOLOGY

- A. Cellular/molecular mechanisms of toxicity
- B. <u>In vitro</u> structure-activity relationships and their quantitative, computational and predictive implications
- C. Molecular biologic markers of toxicity and metabolism
- D. Physiologically based pharmacokinetic (PBK) modeling of toxic Air Force chemicals

II. RADIATION (NON-IONIZING) TOXICOLOGY

A. Interaction of sub-nanosecond laser pulses with ocular and dermal tissues

B. Radiation effects on genetic apparatus and cellular biochemistry

C. Radiation effects on structural/functional components of tissues and organ systems

D. Biophysical and mathematical modeling of radiation-induced damage

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Mathematics and Space Sciences

Mathematics and Space Sciences

The Directorate of Mathematics and Space Sciences is responsible for basic research in mathematical and computer sciences and space sciences in the areas described in this section. Many critical research activities are multidisciplinary and involve support from the other scientific directorates within AFOSR. Such activities include joint research with the Directorate of Physics and Electronics in the design of high-power microwave devices and joint research with the Directorate of Chemistry and Life Sciences in intelligent tutoring. The control theory and mathematical modeling research supported by this directorate complements many structural, fluid mechanics, and propulsion research programs supported by the Directorate of Aerospace and Materials Sciences.

Dynamics and Control

This program is devoted to basic research in dynamics and control, leading to improved techniques for the design and analysis of control systems with enhanced capabilities and performance for use in future Air Force missions. Proposals should be linked to appropriate Air Force applications, which currently include the development of robust feedback controllers for advanced high-performance aircraft and adaptive, reconfigurable flight control systems; control sensors and actuators; control of fluid flow processes associated with aerospace vehicles; the control of low-signature, tailless, combat aircraft and the control of electromagnetic radiation by mastering the properties of a propagating surface; control and optimal design issues in aeroengines; imaged tracking and robust feedback control in high scintillation environments; control of autonomous aerial vehicle systems; and novel hybrid control systems that can intelligently manage actuator, sensor, and processor communications in complex spatially distributed systems. We emphasize research in distributed-parameter control (including control of complex coupled fluid-structure systems); robust, adaptive multivariable feedback control for both linear and nonlinear systems; multidisciplinary design optimization; and, to a lesser degree, fundamental applied research in stochastic control, control of discrete event dynamical systems, and use of neural networks for control design.

Research in robust multivariable feedback control will develop mathematical methods that allow the design and analysis of feedback systems that achieve stability and satisfy other performance objectives in the face of uncertainties. There is increased interest in the development of a theory of robust control for nonlinear and distributed-parameter systems, as well as in novel approaches to effective robust-control-oriented system identification techniques. Support for research in linear systems theory is decreasing.

Distributed-parameter control problems involve systems with dynamics given by partial differential equations, integrodifferential equations, or equations with delays. New integrated approaches are needed to develop approximation techniques for the identification, control, and optimization of distributed-parameter systems. Although efforts continue at a decreased level in dynamics and control theory for flexible structures, increased attention is focused on mathematical techniques that support the development of modern theory applicable to controlling fluid flow and combustion processes as well as complex, highly nonlinear coupled interactions between structural deformation and unsteady flows. These research efforts are coordinated with ongoing efforts in aerospace engineering that emphasize experimental research.

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Physical Mathematics and Applied Analysis

This program pursues mathematical models and their analysis in areas of interest to the Air Force. Our goal is to distill focused mathematical models of particular physical phenomena and the mathematical methods for their analysis, as well as to produce models sufficient for numerical computation. The payoffs include understanding and modeling physical phenomena (e.g., nonlinear optics, turbulent flow) leading to methods for their simulation and control.

Although it supports a broad range of topics, this program concentrates on several special interests: nonlinear optics, mathematical materials science, theoretical fluid mechanics (including transonics, hypersonics, and local meteorological changes to the atmosphere's index of refraction), combustion/detonation, and orbital mechanics of various satellites. All of these areas have in common the nonlinearity of their mathematical descriptions. Nonlinear mathematics exhibits a spectrum of behavior for which effective mathematical understanding is either unavailable or only beginning to emerge. What is striking is the ubiquitous appearance of coherent structures (solitons and their relatives), chaotic solutions, or formation of singularities in many seemingly disparate physical scenarios. Research emphasizes both analytical and numerical tools in tackling these problems.

One goal of nonlinear optics is the effective exploitation of lasers. Solitons, chaos, and other operational possibilities that affect beam control, imaging, and diode array stability are stressed.

Recent work in mathematical materials science involves a blend of nonconvex energy integrands and modern variational approaches that attempt to incorporate measure theory and homogenization in a computationally useful way. It is anticipated that insight into the design of smart skins and exotic composites would be furthered by such research. Other areas include models of structured continua (including liquid crystal polymers) and effective media theory.

Research in fluid mechanics could seek to include real gas effects and rarefied flow regimes as well as stores separation in transonic flight. Nonlinear stability, important distinguished limits, and clarification of unresolved issues in noncontinuum models are other areas of interest.

Research in the mathematics of combustion/detonation is expected to shed light on questions arising in the burning of solid rocket propellant as well as the design of improved or specialized warheads.

The description of orbiting platforms should embrace recent results from nonstandard Hamiltonian mechanics so that important details of satellite attitude can be captured.

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Computational Mathematics

This program aims to develop improved mathematical methods and algorithms that exploit advanced computational capabilities in support of Air Force scientific computing interests. For the most part, this program seeks to develop innovative methods and algorithms that improve modeling and simulation capabilities. These improved capabilities, in turn, enable understanding, prediction, and control of complex physical phenomena crucial to the Air Force. These phenomena include fluid mechanics, combustion processes, structural dynamics, high-cycle fatigue in turbine engines, control of large flexible structures, HEDMs, crystal growth, processing and performance of composite and tailored materials, weather modeling, plasma dynamics, and electromagnetic pulse generation. Research in the Computational Mathematics Program enables technological advances in structural integrity, airbreathing propulsion, rocket and space propulsion, aerodynamics and hypersonics, and high-power microwaves. Our research also supports the national agenda in high-performance computing.

We are developing numerical methods and algorithms to exploit fully the potential of parallel computing for fast, accurate numerical solutions of complex systems occurring in both the engineering design of Air Force systems and their operation. Efficient use of available parallel machines requires that we pay increased attention to dynamic resource allocation and load balancing, domain decomposition techniques, scalable parallel algorithms, adaptive meshing for shock tracking, and parallel schemes for adaptive grid generation. As the cost of hardware continues to decrease, the results of this program may affect the design of specialized architectures for solving critical scientific problems.

Typically, the computational models in this program rely on some numerical scheme that implements a discretization of continuum mechanics equations--generally partial differential equations--that represent the physics of the situation. However, alternative computational models may be appropriate for many problems. To characterize the behavior of large, complex, real-world systems, we are examining modeling approaches that enable efficient, robust multidisciplinary design analysis and optimization. Overall, we are investigating both traditional and radical approaches in this program. We are developing and improving a variety of numerical methods in this subarea, including homogenization techniques, continuation methods, finite elements, particle and vortex methods, finite difference methods, essentially nonoscillatory methods, and spectral methods. In addition, fast, accurate, and robust methods for solving large systems of linear equations lie at the heart of many scientific computing problems of interest to the Air Force. For this reason, computational linear algebra, especially multilevel or multigrid techniques, continues to receive attention. This emphasis, however, is diminishing.

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External Aerodynamics and Hypersonics

The External Aerodynamics and Hypersonics program is a fluid dynamics research program. Thrusts in the numerical simulation of unsteady, multi-disciplinary fluid dynamic flows over maneuvering weapon systems are supported. This program is the central hypersonics research program at AFOSR. This research program seeks to improve the fundamental understanding of viscous and inviscid fluid dynamic phenomena that strongly influence the mission requirements-driven design, aerodynamic performance, and efficiency of hypersonic and supersonic Air Force multi-disciplinary flight vehicle weapon systems. This includes hypersonic flight vehicles, which will enter into low earth orbit space environments. Proposals in rarefied gas dynamics to support the Air Force thrust in Space is sought. Experimental efforts are not part of this program and are handled in the Aerospace and Materials Sciences Directorate (NA)

Research in advanced computational fluid dynamics (CFD) is sought to develop full three-dimensional autoadaptive, unstructured grid methods. Currently methods of simulating the complex, three-dimensional, time-dependent flows created by aircraft and missile platforms during dynamic combat maneuvers are being researched. Research is also sought to address flows with multiple bodies in relative dynamic motion, such as store separation or air-to-air missile engagements. These full Navier-Stokes simulations include viscous effects that range from laminar, through transitional, to fully turbulent boundary layer states. Of particular importance is the development of advanced large-eddy simulation (LES) and direct numerical simulation (DNS) methods for high-speed, viscous, compressible flows over aircraft and missile components (wings/fins and fuselages), as well as internal flows in supersonic engine inlets and hypersonic SCRAMJET inlet systems. LES methods using spectral element or other DNS subgrid scale simulations are of particular interest. We are also interested in developing analytical capabilities for dynamic, three-dimensional, viscous, hypersonic engine inlet unstart processes for single as well as multiple scramjet bank systems. Research in unsteady aerodynamics should reveal the fundamental viscous processes associated with vorticity generation within the boundary layer along wing leading edges, the mechanisms responsible for the transfer of that vorticity through feeding sheets from within the boundary layer into discrete vortices outside the boundary layer, and the convection of those vortices once they are shed from the boundary layer into the free-stream flow around and beyond the wing. Research to identify the influence of wing leading edge geometry and aircraft motion on these processes is also sought. It is critically important to develop nondissipative CFD algorithms that are capable of tracking multiple shed vortices with no diffusive loss of vorticity. This includes phenomena related to vortex convection, vortex surface impingement, and multiple vortex coalescence.

Research into the complex flows inside rotating turbomachine engines is sought. The goal is to develop fluid dynamic simulations of multiple blade row (compressor/turbine) airbreathing engines. The dynamic structural interaction which occurs over the compressor/turbine blades is a key requirement.

Research in hypersonics should improve the understanding of complex, time-dependent, three-dimensional viscous flows with and without finite-rate chemistry effects, and should advance the accuracy of full hypersonic configuration numerical simulation methods. Hypersonic maneuverability is of particular importance. Research into the aerothermo-structural deformation of maneuvering hypersonic flight vehicles (missiles/global reach vehicles/earth to orbit) is strongly sought. Boundary layer stability and transition analyses for aerothermodynamic flows over hypersonic flight vehicles based on the spatial and temporal evolution of turbulence structures are also of primary interest. DNS methods which include rate chemistry effects on turbulence are also sought.

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Optimization and Discrete Mathematics

Our goal is to develop mathematical methods for solving large or complex problems, such as those occurring in logistics, engineering design, and strategic planning. These problems can often be formulated as mathematical programs. Therefore, research is directed at new linear and nonlinear programming methods, especially when formulated for the solution of selected Air Force problems. There is a significant increased emphasis on planning and scheduling under the Air Force's New World Vistas program. We are particularly interested in innovative techniques that combine the use of artificial intelligence and operations research.

This emphasis includes interaction between the collaborators, both human and machine. In addition, it will require new analytic techniques for development of robust plans under dynamic changes and uncertainty; that is, plans which perform well under a range of possible scenarios and can be changed to accommodate new conditions with minimal perturbation. This will enhance our existing research in robust optimization. In addition, modeling techniques to rapidly accommodate new information such as battle damage assessment and data fusion will be needed. These techniques should be designed to handle data that is possibly incomplete, conflicting or overlapping. These models will view planning, execution, information acquisition, and replanning as a continuously evolving process.

In addition to the evolution of traditional solution methods, the program supports new algorithmic paradigms (e.g., simulated annealing, genetic algorithms). We support research in discrete event systems, especially as it relates to Air Force transportation, manufacturing, command and control systems, and battlefield management. We are particularly interested in the control of discrete event systems through models that combine simulation and optimization

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Signals Communication and Surveillance

This research activity is concerned with the systematic analysis and interpretation of variable quantities in media that are intended to convey information. Communications signals and surveillance images are of special importance. Signals are physically generated, propagated through electromagnetic or other media, and recaptured for use at a receiving mechanism. Modern radar, infrared, and electro-optical sensing systems produce large quantities of raw signaling that exhibit hidden correlations, are vulnerable to distortion by noise, and retain features tied to a particular physical origin. Statistical research that treats spatial and temporal dependencies in such data is necessary to exploit the usable information within.

An outstanding need in the treatment of signals is to develop resilient algorithms for data representation in fewer bits (compression), image reconstruction/enhancement, and spectral/frequency estimation in the presence of external corrupting factors. These factors can involve deliberate interference, noise, ground clutter, and multipath effects. We maintain involvement with sophisticated mathematical methods, including time-frequency analysis and generalizations of the Fourier and wavelet transforms, that deal effectively with the degradation of signaling transmission across a channel. These methods hold promise in the detection and recognition of characteristic transient features, the synthesis of hard-to-intercept communications links, and the achievement of faithful compression and fast reconstruction for audio and video data.

The Air Force has a responsibility to interpret and use data in the logistics and human resource management arena. The methods of probability modeling have proven effective in upgrading the performance of both human and automated systems. Research toward even better use of such modeling techniques promises to improve existing systems architectures and to streamline the testing and evaluating of new systems. We emphasize those probabilistic methods in which prior information can meaningfully be integrated into the performance-monitoring process, with a view toward achieving an optimal degree of situation awareness as well as reactive capability during combat.

With an ever-improving repertoire of signal processing and statistical tools, the Air Force will maintain its lead in communications flexibility, command an encompassing scope in signal detection and processing, and project air power through efficient and responsive systems, all at a manageable cost.

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Software and Systems

The goal of this research program is to develop advanced computing technology to support future Air Force needs in battlespace information management. Computing research is sought to meet several challenges: control and integration of the vast amounts of information flowing through battlespace computer networks, protection of friendly information resources, and complexities in software and algorithm development in support of dynamic planning and execution control.

The need to collect, integrate, and disseminate information from widely disparate sources will be crucial in future military operations. Basic research is needed in a number of areas to build battlespace information systems of the future. For example, mathematical foundations of information fusion must be established -- robust, integrated fusion architectures for handling increasing diversity of input sources are especially important. We are also interested in foundational approaches to the specification and design of agents for network management, for information retrieval, filtering, summarizing, and for planning.

For network protection, researchers will focus on determining and analyzing network security properties at all network layers and examining how to ensure that a network possesses these properties. New approaches to intrusion detection and attack recovery are also needed. Basic research that anticipates the nature of future information system attacks is critical to the survivability of these systems.

In the area of software and algorithm development, we seek mathematical approaches for the specification, design, and analysis of distributed software systems. Rigorous mathematical methods, especially those that involve aspects of timing, control, dependability, and security, will be crucial to development of future battlespace information systems. New approaches for overcoming the increasing computational complexity of these systems are essential.

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Artificial Intelligence

The timely management of information, and the ability to make decisions based on that information, is of paramount importance within this program. The key issue that we are addressing is how to effectively incorporate all available information, from diverse sources and modalities, into the decision process. To understand this issue, we are sponsoring research into ways to make the best use of uncertain information; share and disseminate information; increase the accuracy, speed, and economy of the recognition and identification process; and aid the intelligence analyst.

The program concentrates on research needed to develop large-scale intelligent systems that can address practical Air Force needs. To that end, we seek means to scale up those methods that work for small knowledge-based systems. We need to overcome present limitations in the amount of knowledge used because of knowledge acquisition and management deficiencies. Present limitations on meaningful systems adaptation and improvement with use also need to be overcome. Formalisms need to be developed for the representation of and reasoning with uncertainty, handling corrupt information, and effectively using experiences.

To aid the information analyst in fusing information from diverse modalities, we seek means to combine numeric and symbolic inference methods. Research could also focus on integrating probabilistic reasoning methods with traditional formal logic methods, and perhaps with other forms of computation. Qualitative methods that will drastically simplify computation and increase performance robustness are also of interest.

We are seeking to develop technology that will support decision-making. To that end, research is needed to develop intelligent agents capable of gathering information, reducing data to a manageable amount of essential information, and cooperating with other agents to solve problems. Research is also needed to combine artificial intelligence methods with operations research tools to overcome inefficiencies in solving some mission-critical Air Force problems (e.g., scheduling in a distributed, dynamic environment).

Intelligent tutoring is an area of increased interest to the Air Force. The focus of this effort is to develop efficient computer-mediated tools for instructional delivery both for training and tutoring, with the objective of reducing personnel needs and optimizing tutoring and training. Adaptive teaching systems that model the trainee and attempt to understand his or her responses by simulating these models is one area supported within this program. Research tasks in intelligent tutoring are linked to the Human Resource Laboratory of the Air Force Armstrong Laboratory, where the evaluation and experimentation with actual trainees occurs.

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Electromagnetics

One emphasis of this program is the development of state-of-the-art antenna systems for communications and radar. Basic electromagnetic radiator research focuses on improvements in efficiency, radiation pattern control, effective bandwidth, impedance matching, and approaches for the control of adaptive phased arrays (both periodically and nonperiodically spaced configurations). Scattering research seeks to characterize and exploit the details of both targets and terrain, together with predicting propagation through dispersive and random media and the use of three-dimensional algorithms, accompanied by rigorous error analysis/control, for scattering by large objects. Our research interests also include high-power microwave (HPM) sources, both narrow and broad band, together with HPM effects on circuitry.

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Upper Atmospheric Physics

A fundamental understanding of the upper atmosphere is essential for improving the Air Force's capability to support military operations.. The physical and chemical behavior of the Earth's upper atmosphere affects the performance of Air Force systems. We require basic knowledge of the structure and chemistry of the mesosphere and thermosphere, as well as the physics and dynamics of the ionosphere. This requirement involves observing and modeling atmospheric tides, gravity waves, variations in solar radiation and high-energy particle fluxes, geomagnetic disturbances and their impacts on the ionosphere, neutral winds, electron density structure, and spectroscopic emission signatures.

Although measurements and observational techniques play an important role in research, significant progress requires programs that carefully combine theory with experiment. Thus we emphasize analyzing observations to extract the fundamental physics rather than purely gathering data. We place the highest priorities on research in ionospheric physics, plasma turbulence and dynamics, ionospheric-magnetospheric coupling, auroral and airglow emissions, and atmospheric propagation of electromagnetic energy (to include radars and lasers). Other topics include remote sensing of upper atmospheric motions and theoretical studies of molecular and spectroscopic parameters pertinent to aeronomy.

Our goals are to improve the global specification and forecasting of the evolution of ionospheric irregularities; improve the specification of thermospheric dynamics and neutral densities; and to validate and enhance ionospheric models using data assimilation techniques to improve operational forecasting and specification capabilities.

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Space Sciences

We require basic knowledge of the space environment for the design and calibration of Air Force systems operating in and through space. Electric and magnetic fields, electromagnetic radiation, space debris, charged particles, and interplanetary dust can degrade the performance of Air Force spacecraft and systems. Both the nominal and disturbed space environment can disrupt the detection and tracking of missiles and satellites, distort communications and navigation, and interfere with global surveillance operations.

Our research interests include, but are not limited to, the hazards to spacecraft caused by space debris, interplanetary dust, asteroids, and comets; the structure and dynamics of the solar interior and their role in driving solar activity; the mechanism(s) responsible for heating the solar corona and accelerating it outward as the solar wind; coronal mass ejections (CMEs) and solar flares; the coupling between the solar wind, the magnetosphere, and the ionosphere; the origin and energization of magnetospheric plasma; and the triggering and temporal evolution of geomagnetic storms.

By specifying the flow of mass, momentum, and energy from the Sun to the Earth, and by forecasting the plasma phenomena that mediate the flow of energy through space, our goal is to develop a global, coupled solar-terrestrial model that connects solar activity with the deposition of energy in the Earth's upper atmosphere.

We are also strongly interested in advanced deep space surveillance techniques to observe and track Near Earth Objects and other physical threats to Air Force systems. In this regard, we are looking for innovative astronomical observation techniques that involve advanced image processing and/or sensor technology. Astrophysical or astronomical research and observations that investigate stellar-planetary interactions in general and physical processes occurring in our sun in particular are also of interest.

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IV. Researcher Assistance Programs

The Directorate of External Programs and Resources Interface (NI) sponsors researcher assistance programs that stimulate scientific and engineering education and increase the interaction between the broader research community and Air Force laboratories and sponsors other studies and/or research deemed appropriate by AFOSR. Applications for these programs do not always require proposals but generally have specific deadlines, formats, and qualifications, which are shown with each program discussed. Researchers applying for these programs should contact the offices listed in each program description.

United States Air Force/National Research Council-Resident Research Associateships (USAF/NRC-RRA) Program

The USAF/NRC-RRA Program offers postdoctoral and senior scientists and engineers opportunities to perform research at sponsoring Air Force laboratories. The objectives of the program are (1) to provide researchers of unusual promise and ability opportunities to solve problems, largely of their own choice, that are compatible with the interests of the hosting laboratories; and (2) to contribute to the overall efforts of the Air Force laboratories.

Postdoctoral Research Associateships are awarded to U.S. citizens and permanent residents who have held doctorates for less than 5 years at the time of application. They are made initially for 1 year and may be renewed for a second year. A small number of associateships may be available for foreign citizens if laboratory funds are available.

Senior Research Associateships are awarded to individuals who have held doctorates for more than 5 years, have significant research experience, and are recognized internationally as experts in their specialized fields, as evidenced by numerous publications in reviewed journals, invited presentations, authorship of books or book chapters, and professional society awards of international stature. Although awards to senior associates are usually for 1 year, awards for periods of 3 months or longer will be considered. U.S. citizenship is not a requirement.

Associates receive a stipend from the NRC while carrying out their proposed research. There is an annual stipend with additional increments for each year past the Ph.D. An appropriately higher stipend is offered to senior associates.

Awardees also receive a relocation reimbursement and may be supported with limited funds for professional travel. The program is managed by AFOSR with external funding.

For additional information, contact:

Associateship Programs (TJ-2114)		AFOSR/NI
National Research Council	-or-	4040 Fairfax Drive

2101 Constitution Avenue, NW
Washington DC 20418
(202) 334-2760
Email: rap@nas.edu
Internet: http://www.nas.edu/rap
Gopher: nas.edu/rap

Arlington VA 22203-1613
(703) 696-7316; DSN: 426-7316
FAX: (703) 696-7320

National Defense Science and Engineering Graduate (NDSEG) Fellowship Program

The NDSEG Fellowship Program is a Department of Defense (DoD) fellowship program sponsored by AFOSR, the Army Research Office, the Office of Naval Research, and the Advanced Research Projects Agency. The DoD selects about 100 Fellows per year; the Air Force sponsors about 25 of those Fellows.

AFOSR has a goal of awarding 10 percent of these fellowships to applicants who are members of an ethnic minority group underrepresented in the advanced levels of the U.S. science and engineering personnel pool (i.e., Native American, Black, Hispanic, Native Alaskan [Eskimo, Aleut], or Native Pacific Islander [Polynesian or Micronesian]).

These fellowships are for study and research in areas of interest to the Air Force. Fellowships are limited to U.S. citizens who have received their B.S. degrees. Air Force graduate fellowships are tenable at any U.S. institution of higher education offering a Ph.D. in science or engineering.

Students receive stipends for each year. Stipends are prorated for fellowship periods of less than 12 months; however, the duration of the fellowship will not be less than 9 months. In addition to the stipend, the Air Force pays the student's tuition and provides $2,000 per year to the student's department.

Those Fellows selected and sponsored by the Air Force will be offered the opportunity to become associated with an Air Force laboratory, but they are not required to spend a summer at an Air Force laboratory.

For more information, contact:

NDSEG Fellowships
AFOSR/NI
4040 Fairfax Drive
Arlington VA 22203-1613
(703) 696-7310 DSN: 426-7310
FAX: (703) 696-7320

V. Special Programs

V. Special Programs

Conferences and Workshops

The Air Force Office of Scientific Research (AFOSR) understands that it is essential for the scientific community to maintain clear lines of communication for thorough and well-reasoned research to be accomplished. Support for conferences and workshops has proven to be an extremely valuable tool for AFOSR. They allow our technical managers the opportunity to receive prevailing information on their respective disciplines. They also allow AFOSR the opportunity to inform the research community of the current thrust of AFOSR's programs. Conferences and workshops constitute a key forum for research and technology interchange.

AFOSR encourages proposals from recognized scientific, technical, or professional organizations that qualify for federal tax exempt status.

AFOSR’s financial support through appropriate financing vehicles for conferences and workshops is dependent on the availability of funds, program manager’s discretion, and certain other restrictions. Other restrictions include:

- AFOSR support for a workshop or conference is not to be considered as an endorsement of any co-sponsoring organization, profit or non-profit.
- The subject matter of the conference or workshop is scientific, technical, or involves professional issues that are relevant to AFOSR’s mission of managing the Air Force basic research program.
- The purpose of our support will transfer federally developed technology to the private sector or will stimulate wider interest and inquiry into the relevant scientific, technical, or professional issues relevant to AFOSR’s mission of managing the Air Force basic research program.

Proposals for conference or workshop support should be submitted a minimum of six months prior to the date of the conference. Proposals should include the following:

Technical Information

- Summary indicating the objective(s) of the conference/workshop
- Topic(s) to be covered and how they are relevant to AFOSR’s mission of managing the Air Force basic research program
- Title, location, and date(s) of the conference/workshop
- Explanation of how the conference/workshop will relate to the research interests of AFOSR identified in Section II or III of the Broad Agency Announcement (BAA)
- Chairperson or principal investigator and his/her biographical information

- List of proposed participants and method (or copies) of announcement or invitation

Cost Information

- Total project costs by major cost elements
- Anticipated sources of conference/workshop income and amount from each
- Anticipated use of funds requested from AFOSR (Note: AFOSR funds may not be used to support or assist participants from communist countries or to pay any federal government employee support, subsistence, or fee in connection with the conference/workshop)

Proposals for conferences and workshops will be evaluated using the following criteria. All factors are of equal importance to each other.

1. The scientific and technical relevance of the proposed conference.
2. The potential contributions of the proposed conference to the mission of the Air Force.
3. The qualifications of the principal investigator(s) or conference chair(s).
4. The realism and reasonableness of cost including proposed cost sharing and availability of funds.

If you have questions concerning the scientific aspects of a potential proposal to AFOSR for conference or workshop support, please contact the program manager listed in Section II or III of the BAA responsible for the particular scientific area of the conference/workshop. If you have questions concerning the eligibility of your organization to receive funding for your conference or workshop, please contact the AFOSR Legal Office at (703) 696-9500.

Air Force Program in Partnerships for Research Excellence and Transition (PRET)

The PRET Program is a university based research program of excellence involving strong industrial ties to accelerate the transition of research results to industry. This program is designed to broaden the university base in support of defense research, strengthen university-industry cooperation, and improve the US competitiveness in areas of dual use. The goal of the program is to fund quality research and concurrently establish and support a deliberate exchange of scientific personnel between academia and industry. The areas to be supported are found in Sections II and III of this announcement. Proposals will be evaluated using the following criteria. The first three factors are of equal importance to each other. The last factors are of lessor importance than the first three, but are of equal importance to each other.

1. The scientific and technical merits of the proposed research.

2. The potential contributions of the proposed research to the mission of the Air Force.

3. The proposed interface between university and industry for the purpose of transitioning the generated information.

4. The likelihood of the proposed effort to develop new research capabilities and broaden the research base in support of national defense.

5. The proposer's principal investor's team leader's, or key personnel's qualifications, capabilities, related experience, facilities, or techniques or a combination of these factors that is integral to achieving Air Force Objectives.

6. The proposer's and associated personnel's record of past performance.

7. The realism and reasonableness of proposed costs and availability of funds. Although not a primary evaluation factor, price is a substantial factor in the selection of proposals for award.

Small Business Technology Transfer Program (STTR)

AFOSR has no Small Business Innovative Research (SBIR) Program, but we do have a very active Small Business Technology Transfer (STTR) Program with a budget of nearly $7,000,000 per year. AFOSR normally has ten topics in the DoD Solicitation that comes out each year in January. These topics are for basic research in areas of special interest to AFOSR. While STTR has the same objectives as SBIR, regarding the involvement of small businesses in federal R&D and the commercialization of their innovative technologies, the STTR program provides a mechanism for participation by universities, federally-funded research and development centers (FFRDCs), and other non-profit research institutions. Specifically, the STTR Program is designed to provide an incentive for small companies, and researchers at academic institutions and non-profit research institutions, to work together to move emerging technical ideas from the laboratory to the marketplace, to foster high-tech economic development and to advance U.S. economic competitiveness. Each STTR proposal must be submitted by a team which includes a small business (as the prime contractor for contracting purposes) and at least one research institution, which have entered into a Cooperative Research and Development Agreement for the purposes of the STTR effort. The STTR has two phases. Phase I efforts are for $60,000 to $100,000 for a period not to exceed one year. Phase II STTR projects are 24 month efforts for amounts up to $500,000.

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Historically Black Colleges and Universities and Minority Institutions (HBCU/MI) Program

AFOSR has an active HBCU/MI program. In addition to sponsoring research at HBCU/MIs, Colonel Jan Cerveny, the Director of the AFOSR External Programs & Resources Interface Directorate (AFOSR/NI) is the executive agent for the Air Force Research Laboratory program. The AFOSR HBCU/MI program has three main components. These are outlined below.

AFOSR Core Research. Research proposals from HBCU/MI selected by AFOSR Program Managers as part of their core program may be funded from special funds set aside by the AFOSR Director for proposals originating at HBCU/MI.

AFOSR FAST Centers. Six Future Aerospace Science and Technology (FAST) Centers were created in 1994 as centers of research excellence at selected HBCU/MIs. With funding averaging $3.2M through year FY 02 these centers are focusing on developing a research capability that will enable them to compete with major research institutions for DoD and defense industry research dollars. These Centers are funded with money supplied by the DDR&E HBCU/MI program.

Department of Defense Infrastructure Support Program for Historically Black Colleges and Universities and Minority Institutions. For the past three years the DoD has been providing grants for research and educational equipment at HBCU/MI. This program is conducted through the Army Research Office, Office of Naval Research and the Air Force Office of Scientific Research HBCU program managers. Schools interested in this program should look for the Broad Agency Announcement that normally comes out in October each year. Grants under this program are for one year and range from $20,000 to $200,000.

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VI. Proposal Guidance

The Air Force Office of Scientific Research (AFOSR) invites proposals for basic research in support of the Air Force Defense Research Sciences Program. Proposers selected for funding may be awarded grants, cooperative agreements, or contracts. The areas of interest are covered in Sections II, III, and V of this pamphlet. This includes proposals for research instrumentation that will support research in areas of interest to the Air Force and DOD. Procedures *for a researcher to apply* for programs noted in Section III are specific to each program. Information and proposal procedures can be requested from the office noted in each program description.

Our overriding purpose in supporting this research is to advance the state of the art in areas related to the technical problems the Air Force encounters in developing and maintaining a superior Air Force; lowering the cost and improving the performance, maintainability, and supportability of Air Force weapon systems; and creating and preventing technological surprise.

Proposals under this Broad Agency Announcement (BAA) can be submitted only to AFOSR, which includes AOARD and EOARD. They are evaluated through a peer or scientific review process, and selected for award on a competitive basis according to Public Law 98-369, Competition in Contracting Act of 1984, 10 U S C 2361, and 10 U S C 2374. Proposals submitted for Special Programs listed in Section V shall be evaluated under criteria as specified in their description. All other proposals will be evaluated under the following two primary criteria, of equal importance, as follows:

1. The scientific and technical merits of the proposed research.

2. The potential contributions of the proposed research to the mission of the Air Force.

Other evaluation criteria used in the technical reviews, which are of lesser importance than the primary criteria and of equal importance to each other, are as follows:

1. The likelihood of the proposed effort to develop new research capabilities and broaden the research base in support of national defense.

2. The proposer's principal investigator's, team leader's, or key personnel's qualifications, capabilities, related experience, facilities, or techniques or a combination of these factors that is integral to achieving Air Force objectives.

3. The proposer's and associated personnel's record of past performance.

4. The realism and reasonableness of proposed costs and availability of funds, although not a primary evaluation factor, price is a substantial factor in the selection of proposals for award.

No further evaluation criteria will be used in source selection. The technical and cost information will be analyzed simultaneously during the evaluation process.

Proposals may be submitted for one or more of the topics in Sections II and III or for a specific portion of one topic. A proposer may submit separate proposals on different topics or different proposals on the same topic. The Government does not guarantee an award in each topic area.

The cost of preparing proposals in response to this announcement is not considered an allowable direct charge to any award made under this BAA or to any other award. It may, however, be an allowable expense to the normal bid and proposal indirect cost specified in the Federal Acquisition

Regulation (FAR) 31.205-18 or Office of Management and Budget Circular A-21 or A-122. Only contracting officers are legally authorized to commit the Government to an award under this BAA.

Technology sharing and transfer is encouraged; in this respect, AFOSR welcomes proposals that envision university-industry cooperation. Nonindustry proposers are encouraged to specify in their proposals their interactions with industry and the Air Force Research Laboratory's Technical Directorates, including specific points of contact. Cooperation with or use of facilities of the Air Force Research Laboratory is also encouraged. Personnel interaction (e.g., university faculty or students performing research at industry or Air Force Research Laboratory sites; industry or Air Force staff working in university laboratories) is viewed as highly desirable.

Central Contractor Registration

a. Definitions.

(1) Central Contractor Registration (CCR) database means the primary DoD repository for information required for the conduct of business with DoD.

(2) Data Universal Numbering System (DUNS) number means the 9-digit number assigned by Dun and Bradstreet Information Services to identify unique business entities.

(3) Data Universal Numbering System +4 (DUNS+4) number means the DUNS number assigned by Dun and Bradstreet plus a 4-digit suffix that may be assigned by a parent (controlling) business concern. This 4-digit suffix may be assigned at the discretion of the parent business concern for such purposes as identifying subunits or affiliates of the parent business concern.

(4) Registered in the CCR database means that all mandatory information, including the DUNS number or the DUNS+4 number, if applicable, and the corresponding Commercial and Government Entity (CAGE) code, is in the CCR database; the DUNS number and the CAGE code have been validated; and all edits have been successfully completed.

b. (1) By submission of an offer, the offeror acknowledges the requirement that a prospective awardee must be registered in the CCR database prior to award, during performance, and through final payment of any award resulting from this solicitation, except for awards to foreign vendors for work to be performed outside the United States.

(2) The offeror shall provide its DUNS or, if applicable, its DUNS+4 number with its offer, which will be used by the contracting or grants officer to verify that the offeror is registered in the CCR database.

(3) Lack of registration in the CCR database will make an offeror ineligible for award.

(4) DoD has established a goal of registering an applicant in the CCR database within 48 hours after receipt of a complete and accurate application via the Internet. However, registration of an applicant submitting an application through a method other than the Internet may take up to 30 days. Therefore, offerors that are not registered should consider applying for registration immediately upon receipt of this solicitation.

c. The offeror is responsible for the accuracy and completeness of the data within the CCR, and for any liability resulting from the Government's reliance on inaccurate or incomplete data. To remain registered in the CCR database after the initial registration, the offeror is required to confirm on an annual basis that its information in the CCR database is accurate and complete.

d. Offerors may obtain information on registration and annual confirmation requirements by calling 1-888-227-2423, or via the Internet at http://ccr.edi.disa.mil.

Certifications: All awards require some form of certifications of compliance with national policy requirements. Assistance awards, i.e., grants and cooperative agreements, require some certifications (e.g., the certification of lobbying) to be submitted at the time of proposal, rather than at the time of award. Proposers may incorporate these certifications into their proposals by reference. This may be accomplished by using AFOSR's Proposal Cover Page (ftp://ftp.fie.com/afr/afrgcvr.doc). A listing of the current certification grants and cooperative agreements is available at AFOSR's World Wide Web site at

http://web.fie.com/htdoc/fed/afr/afo/any/menu/any/afrcert.htm.

Every effort will be made to protect the confidentiality of the proposal and any evaluations. The proposer must mark the proposal with a protective legend in accordance with FAR part 15.6, Use and Disclosure of Data, (modified to permit release to outside evaluators retained by AFOSR) if protection is desired for proprietary or confidential information.

Proposals should briefly address whether the intended research will result in environmental impacts outside the laboratory, and how the proposer will ensure compliance with environmental statutes and regulations.

Unnecessarily elaborate brochures or presentations beyond those sufficient to present a complete and effective proposal are not desired. Proposals may be submitted as hard copy or by electronic media (floppy disk or CD-ROM in Word or Portable Document File (PDF) format). A signed copy of AFOSR's Proposal Cover Sheet must be submitted with all proposals

Proposals may be submitted at any time to the appropriate AFOSR program manager or directorate (addresses are found in Section VII). There will be no further solicitations. Historically Black Colleges and Universities (HBCUs) and Minority Institutions (MIs) are encouraged to apply. In case of difficulties in determining the appropriate AFOSR addressee, proposals may be submitted to:

AFOSR/PKC
801 North Randolph Street, Room 732
Arlington VA 22203-1977

For additional guidance on the form and content of proposals, proposers should refer to the "How to Apply for a Grant or Contract" selection, which can be located in the "Doing Business with AFOSR" section of our World Wide Web site, http://www.afosr.af.mil

This announcement is AFOSR BAA 2000-1 and supersedes the AFOSR Pamphlet 64-1 of 1 October 1997, Research Interest Brochure AFOSR BAA 2000-1. This announcement is open-ended until revised and should be referenced on all responses.

VII. Directories

Organizational Directory

ORGANIZATION	ADDRESS	NAME AND TELEPHONE NUMBER
Air Force Office of Scientific Research (AFOSR)	AFOSR 801 North Randolph Street Room 732 Arlington VA 22203-1977	Janni, Joseph F., Dr., Director (703) 696-7554; DSN 426-7554 FAX: (703) 696-9556
		Reznick, Steven G. Col, Deputy Director (703) 696-7551; DSN: 426-7551 FAX: (703) 696-9556
		Carlson, Herb, Dr., Chief Scientist (703) 696-7551; DSN: 426-7551 FAX: (703) 696-9556
		Caggiano, Marshall L., Lt Col Staff Judge Advocate (703) 696-9705; DSN: 426-9705 FAX: (703) 696-7360
Directorate of Contracts	AFOSR/PK	Hawkins, Edwin C., Mr., Director (703) 696-5903; DSN: 426-5903 FAX: (703) 696-9733
Directorate of Aerospace and Materials Sciences	AFOSR/NA	Schwartz, Lyle H., Dr., Director (703) 696-8457, DSN: 426-8457 FAX: (703) 696-8451
Directorate of Physics and Electronics	AFOSR/NE	Agee, Jack, Dr., Director (703) 696-8570; DSN: 426-8570 FAX: (703) 696-8481
Directorate of Chemistry and Life Sciences	AFOSR/NL	Haddad, Genevieve, Dr., Director (703) 696-7733; DSN: 426-7733 FAX: (703) 696-8449
Directorate of Mathematics and Space Sciences	AFOSR/NM	Rhoades, Clifford, Dr., Director (703) 696-7797; DSN: 426-7797 FAX: (703) 696-8450
Directorate of External Programs & Resources Interface	AFOSR/NI	Cerveny, Jan, Col, Director (703) 696-7310; DSN: 426-7310 FAX: (703) 696-7320
European Office of Aerospace Research and Development (EOARD)	EOARD/CC PSC 802, Box 14 FPO AE 09499-0200 or	O'Connor, Gerald, Col Commander (011) 44-171-514-4376; DSN: 235-4376;
	223/231 Old Marylebone Road London NW1 5TH	FAX: (011) 44-171-514-4960

	United Kingdom	
Asian Office of Aerospace Research and Development (AOARD)	AOARD Unit 45002 APO AP 96337-0007 or 7-23-17 Roppongi, Minato-ku Tokyo 106-0032 Japan	White, Koto, Dr., Director (011) 81-3-5410-4409; DSN: 315-220-4409; FAX: (011) 81-3-5410-4407
AFRL Human Effectiveness Directorate	AFRL/HE 2610 Seventh Street Wright-Patterson AFB OH 45433-7901	Boff, Kenneth, Dr., Chief Scientist (937) 255-6327; DSN: 785-6327 FAX: (937) 904-8034
AFRL Information Directorate	AFRL/IF 26 Electronic Parkway Rome NY 13441-4514	Graniero, John, Mr., Chief Scientist (315) 330-4512; DSN: 587-4512 FAX: (315) 330-4037
AFRL Materials & Manufacturing Directorate	AFRL/ML 2977 P Street, Suite 1, Bldg 653 Wright-Patterson AFB OH 45433-7734	Adams, W. Wade, Dr., Chief Scientist (937) 255-6825; DSN: 785-6825 FAX: (937) 656-4068
AFRL Propulsion Directorate	AFRL/PR 1950 Fifth Street, Bldg 18A Wright-Patterson AFB OH 45433-7251	Garscadden, Alan, Dr., Chief Scientist (937) 255-2246; DSN 785-2246
AFRL Sensors Directorate	AFRL/SN 80 Scott Drive Hanscom AFB, MA 01731-2909	Wittmann, Horst, Dr., Acting Chief Scientist (781) 377-3700; DSN: 478-3700 FAX: (781) 377-3469
AFRL Air Vehicles Directorate	AFRL/VA 2130 Eighth Street, Suite 1, Bldg 45 Wright-Patterson AFB OH 45433-7542	Paul, Donald, Dr., Chief Scientist (937) 255-7329; DSN: 785-7329 FAX: (937) 255-3438
Eglin Research Site Munitions Directorate	AFRL/MN 101 West Eglin Blvd Suite 101 Eglin AFB FL 32542-6810	Sierakowski, Robert, Dr., Chief Scientist (850) 882-6167; DSN: 872-6167 FAX: 850-882-3006
Kirtland Research Site Directed Energy Directorate	AFRL/DE 3550 Aberdeen Avenue SE Kirtland AFB, NM 87117-5776	Hogge, Charles, Dr., Chief Scientist (505) 846-0862; DSN: 246-0862; FAX: (505) 853-1753
Space Vehicles Directorate	AFRL/VS 3550 Aberdeen Avenue SE Kirtland AFB NM 87117-5776	Fender, Janet, Dr., Chief Scientist (505) 846-2604; DSN: 246-2604 FAX: (505) 846-6689

Alphabetical Directory

Agee, Jack, Dr. (703) 696-8570; DSN: 426-8570; jack.agee@afosr.af.mil

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Bellaire, Paul, Maj (703) 696-8411; DSN: 426-8411; paul.bellaire@afosr.af.mil

Berman, Michael R., Dr. (703) 696-7781; DSN: 426-7781; michael.berman@afosr.af.mil

Beutner, Tom, Dr. (703) 696-6961; DSN: 426-6961; tom.beutner@afosr.af.mil

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